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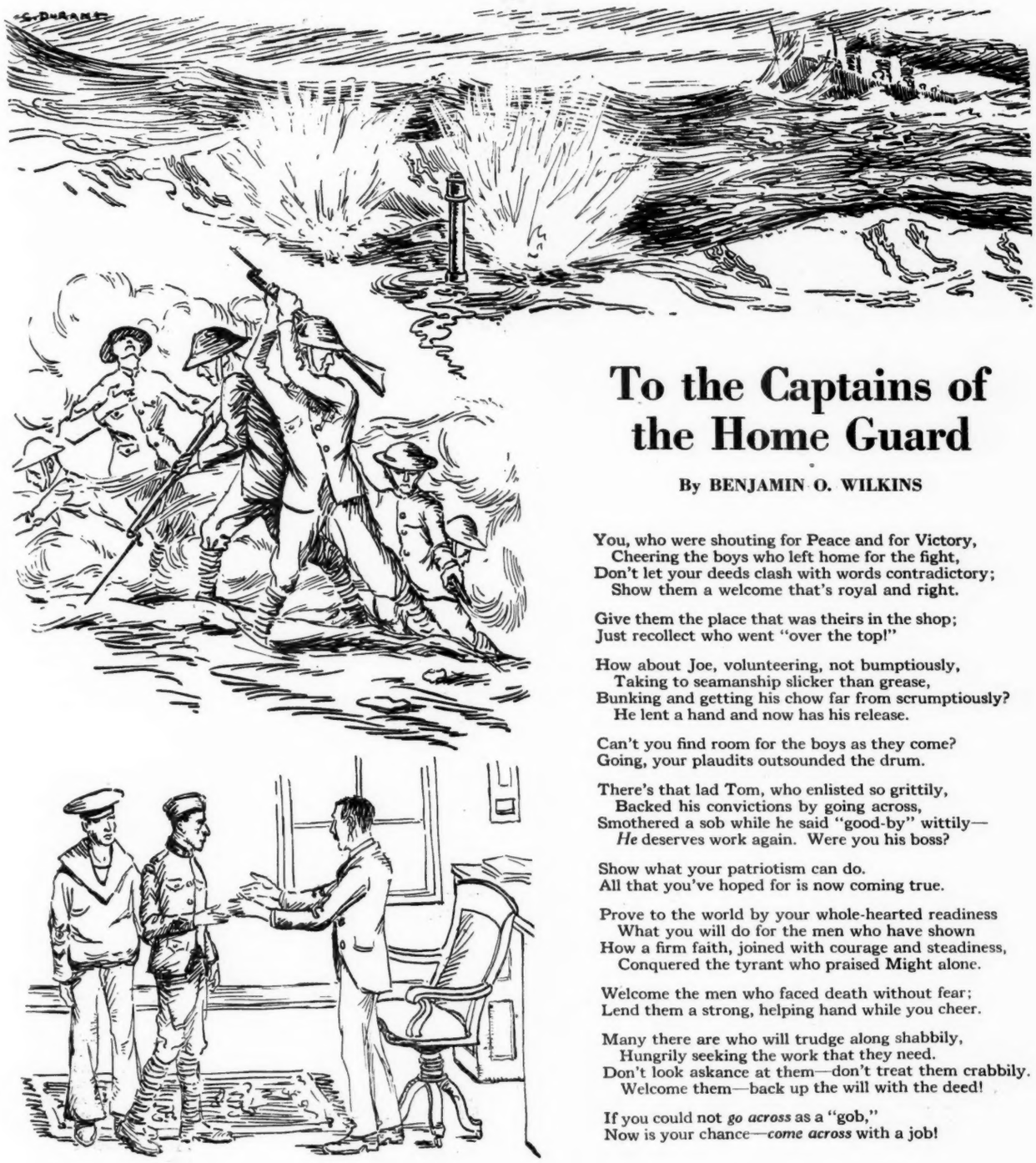

To the Captains of the Home Guard

By BENJAMIN O. WILKINS

You, who were shouting for Peace and for Victory,
Cheering the boys who left home for the fight,
Don't let your deeds clash with words contradictory;
Show them a welcome that's royal and right.

Give them the place that was theirs in the shop;
Just recollect who went "over the top!"

How about Joe, volunteering, not bumptiously,
Taking to seamanship slicker than grease,
Bunking and getting his chow far from scrumptiously?
He lent a hand and now has his release.

Can't you find room for the boys as they come?
Going, your plaudits outsounded the drum.

There's that lad Tom, who enlisted so grittily,
Backed his convictions by going across,
Smothered a sob while he said "good-by" wittily—
He deserves work again. Were you his boss?

Show what your patriotism can do.
All that you've hoped for is now coming true.

Prove to the world by your whole-hearted readiness
What you will do for the men who have shown
How a firm faith, joined with courage and steadiness,
Conquered the tyrant who praised Might alone.

Welcome the men who faced death without fear;
Lend them a strong, helping hand while you cheer.

Many there are who will trudge along shabbily,
Hungrily seeking the work that they need.
Don't look askance at them—don't treat them crabbily.
Welcome them—back up the will with the deed!

If you could not *go across* as a "gob,"
Now is your chance—*come across* with a job!

NEW BOILER PLANT of the A. S. & R. CO. at Omaha,

By R. N. Robertson*

Underfeed stoker plant burning Iowa coal at high maintained efficiencies and with a minimum of operating troubles. Two boilers, interconnected and placed in one setting, are baffled to fully utilize the radiant energy from the fire, and for the same reason the superheater is placed behind the brige-wall. Large furnace volume is provided. The construction in the walls of the setting is unusual. General features of the plant are simplicity, low initial cost, accessibility and minimum labor requirements.

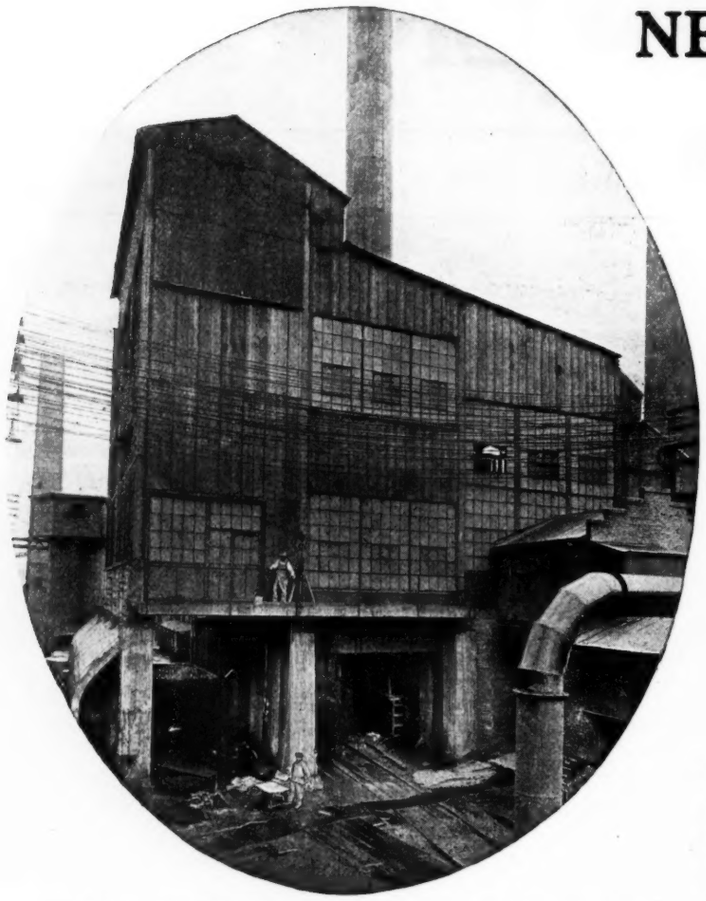

FIG. 1. EXTERIOR OF THE NEW A. S. & R. CO. BOILER PLANT AT OMAHA

EARLY in 1916 the increasing demands for power and for steam for process work made it apparent that additional boiler capacity would shortly be needed at the Omaha Plant of the American Smelting and Refining Co. Because of threatened shortage of labor and the lack of avilable ground space, only two courses seemed to be open—to remodel the old boiler plant into a relatively modern one or to install a new and thoroughly up-to-date plant designed for high operating capacity. After a careful study of conditions it was decided to install the first unit of a four-unit new boiler plant to relieve the immediate acute demand for steam.

In the design of this plant the following considerations were used as a basis and all details were worked out in consonance with them:

1. The demand for steam is continuous 24 hours per day, 365 days per year.

2. The labor required for coal and ash handling and the operation of the plant must be a minimum.

3. The mechanical equipment for handling the coal and ash must be of the simplest mechanical nature consistent with the service to be rendered.

4. All equipment must be of such character as to render repair and replacement easy, simple and cheap, and as far as possible must be of such character and so installed as to render running repairs possible Consequently, it must be readily accessible at all times and under all conditions.

5. The capacity obtainable from the boilers and the other equipment should be a maximum on account of the limited ground space available for future extensions.

6. The design of the plant should be such that new units can be added at any time without the necessity for making any except minor changes in arrangement

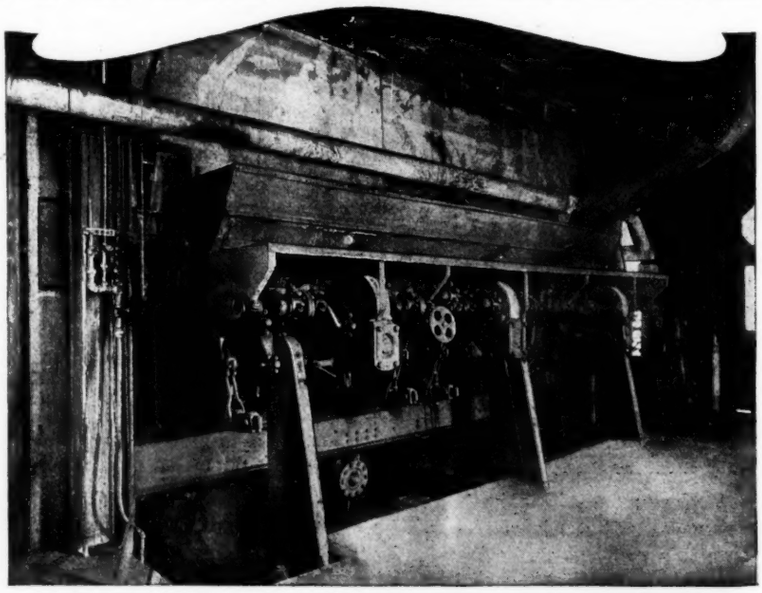

FIG. 2. BOILER FRONT, SHOWING ELEVEN-RETORT UNDERFEED STOKER

*Chief engineer, American Smelting and Refining Company.

to meet the requirements of the most modern equipment at the time the new units are installed.

Figs. 1 and 3 show the arrangement finally decided upon as most nearly fulfilling the requirements previously set forth. It will be seen that no basement has been provided, the first floor resting on concrete columns, so that coal and ash cars can pass underneath. The building itself is of simple, cheap construction, providing plenty of light and ventilation. The plant is without frills of any kind, and all expenditures were considered from the viewpoints of reliability, economy and accessibility.

The fuel available, and on which the designs of the boilers, furnace and the setting were based, is Iowa steam coal running about 14 per cent. moisture, 31 per cent. volatile matter, 35 per cent. fixed carbon and 20 per cent. ash as fired. This coal has a heat value of about 9000 B.t.u. and a sulphur content of about 6 per cent. as fired. The ash from this fuel forms large, sticky and in some cases fluid clinkers, extremely hard to handle, very tough when hot and of a stony hardness when cold. This condition, coupled with the necessity for obtaining high continuous capacity and economy, led to the decision to install inclined underfeed stokers of large retort capacity per boiler horsepower of rating, so that high capacity could be obtained with moderate rates of combustion.

The major equipment of the new boiler plant consists of two 406-hp. water-tube boilers, interconnected, provided with steam purifiers and set over one 11-retort 17-tuyereplate inclined underfeed stoker, Fig. 2, equipped with steam-operated power ash-dump plates and a vertical engine on the first floor for driving. The superheater contains approximately 100 sq.ft. of surface. The forced-blast fan is geared to a 65-hp. steam turbine, controlled by a compensated damper regulator for varying the speed of the fan to meet the steam requirements. A 6-ton monorail crane fitted with a 1¾-yd. clamshell bucket transfers the coal from the railroad cars to the overhead bunker. On its way to the stoker the coal is weighed by a manually operated traveling-hopper coal scale.

The instrument equipment for the boiler room consists of an indicating, recording and integrating steam-flow meter; a continuous recording throttling steam calorimeter between the boilers and the superheater; recording thermometers on the superheater, stack and feed water; recording steam-pressure gage, a recording water-level gage, a recording CO_2 meter, a revolution counter for the stoker plungers, a recording gage for the blast pressure in the windbox, indicating draft gages for observing the stack and the furnace drafts and permanent weighing tanks for boiler testing. The unit is also provided with a nonreturn stop valve in the steam line, graduated feed type of feed-water regulator in duplicate, the usual equipment of pop safety valves and manually operated blowoff and feed-water valves.

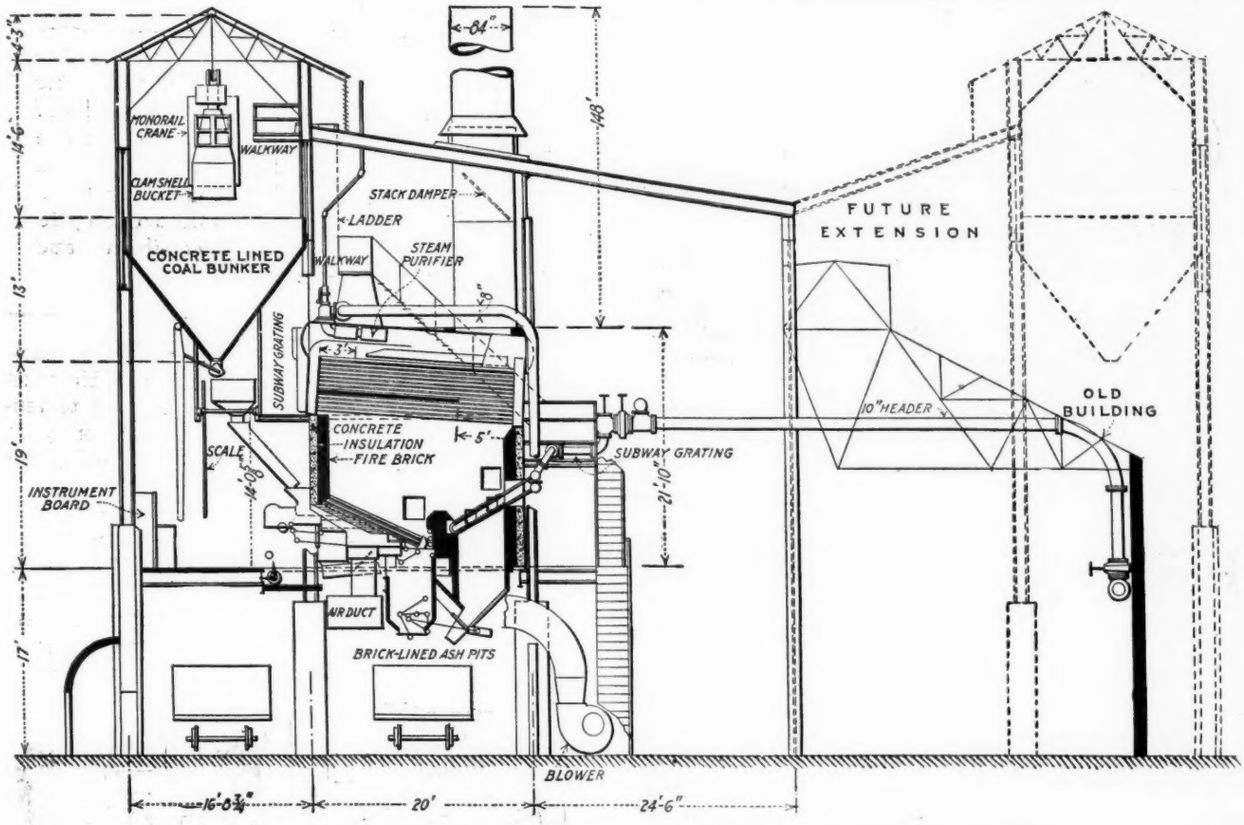

FIG. 3. SECTIONAL ELEVATION OF THE BOILER ROOM AT THE OMAHA PLANT

It will be seen that the equipment installed is standard in every respect. The arrangement and the proportions of the installation are, however, rather unusual, but have proved their value in operation.

The designer of this plant believed that the development of the inclined underfeed stoker must necessarily soon cause a decided change in the general standard of boiler units, tending toward larger areas exposed to the radiant energy of the furnace and comparatively smaller tube areas exposed to the gases of completed combustion, and that for this class of service large

furnace areas and combustion volumes were essential to economy and capacity. For example, it was believed that a horizontal water-tube boiler consisting of 462 tubes arranged 33 wide and 14 high and horizontally baffled to expose the lower three rows of tubes to the radiant energy of the fire would give better capacity and economy than would the same boiler arranged 22 wide and 21 high, and vertically baffled to expose only

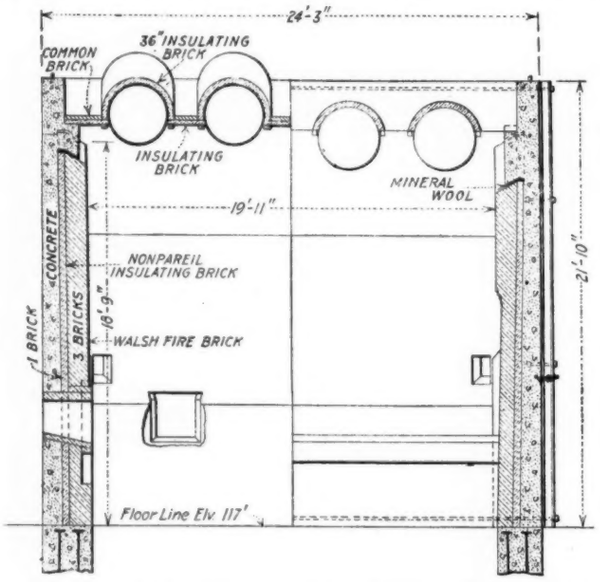

FIG. 4. TRANSVERSE SECTION THROUGH SETTING

one-half the bottom row of tubes to the radiant energy of the fire.

The former arrangement was used in this case and produced a furnace 19 ft. 6 in. wide, 14 ft. high from the boiler-room floor to the bottom of the front water-leg and 9 ft. 6 in. from the front wall of the boiler to the low bridge-wall, which was originally built 2 ft. high with 7-ft. flame space over it, but later increased in height to 3 ft. 6 in. in order to shadow the superheater a little and thus reduce the superheat. The baffle tiles were originally installed on the third row of tubes from the bottom, but were later moved to the fifth row of tubes after refiguring the gas velocities through the boiler.

Experience in the old boiler room indicated that much trouble might be expected from clinker adhesions to the bridge and side walls of the furnace. To provide against this, waterbacks were installed along both side walls and across the bridge-wall. They have prevented trouble from clinker adhesions to either the side walls or the bridge-wall. The water from these waterbacks goes to a softener and comprises the greater part of the makeup required for the boiler feed. It seems probable that the number of pipes in the bridge-wall waterback might safely be reduced to two or possibly to one with a reduction in the amount of water required for cooling.

This plant has frequently handled successfully and disposed of clinkers 4 ft. square and 18 in. thick without difficulty and without unusual effort on the part of the fireroom attendants. Frequently, also, coal has been burned that produced liquid ash that ran through the dump plates in streams. This condition neither reduced the capacity of the plant nor added to the labor of the fireman.

The unit is provided with an ash hopper approximately 20 ft. long by 6 ft. deep by 5 ft. wide, divided into three compartments, each compartment having an opening at the bottom 30 in. wide and 60 in. long. Each of these openings is closed normally by a pan about 6 in. deep arranged to form, when closed, with the bottom of the hopper, a water seal to prevent the inflow of air behind the fire, and thus reduce the excess air from this source. Each pan is power-operated to deliver the ashes from the hopper to a railroad car placed directly below the setting of the boiler.

Combustion ash hoppers are provided beneath the superheater to catch the combustion ash and dust blown over from the fire. These hoppers can be cleaned out while the boiler is in operation, discharging the combustion dust into the same ash car as the main hoppers.

With the idea of making all possible use of the radiant

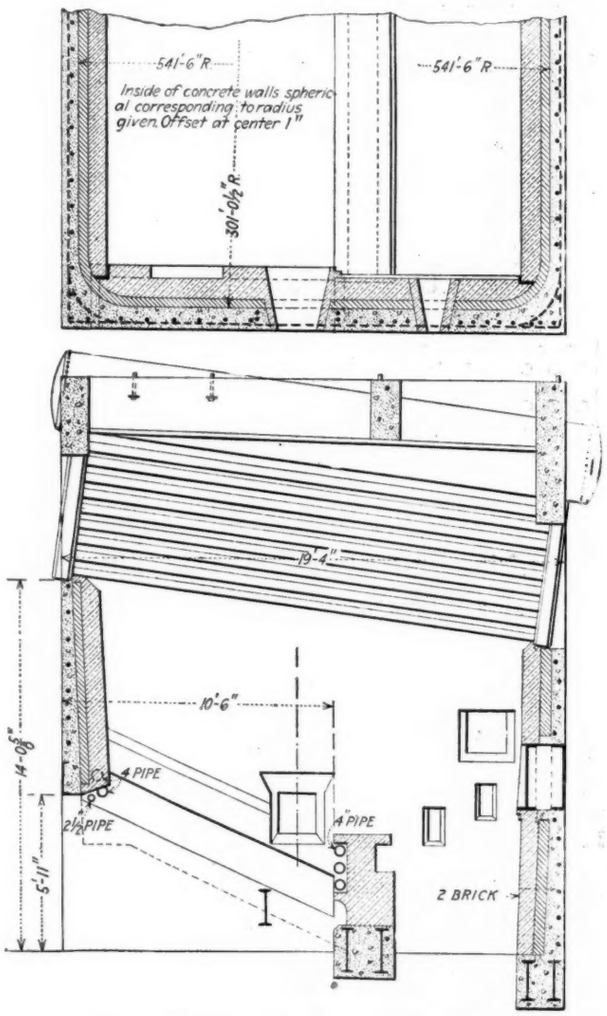

FIG. 5. SECTIONAL PLAN AND LONGITUDINAL ELEVATION, SHOWING SETTING WALL CONSTRUCTION

energy of the fire in the furnace, which energy should vary almost directly with the total heat released in the furnace and consequently with the steam produced by the unit, it was decided to install the superheater in the opposite end of the setting from that occupied by the stoker, and to incline the loops of the elements downward toward the bridge-wall. With this arrangement, no hot gases pass through the superheater elements and all the superheat obtained is direct from

the radiant energy of the fire bed and the burning gases in the furnace. Due to the position of the headers the superheater is automatically self-flooding. This arrangement has worked out in a very satisfactory manner, giving nearly uniform superheat under all conditions of load and delivering properly superheated steam to the header both when going onto the line after a shutdown and when sudden demands for steam are made upon the unit. The superheating is done entirely by the radiant energy of the fire, which in most settings tends to melt the firebrick and raise the furnace temperatures to an abnormal point.

The setting for this unit, Figs. 4 and 5, consists of a monolithic outer coating of concrete about 9 in. thick, heavily reinforced. To this concrete shell are bolted all the access doors to the interior of the setting, and it is designed to carry the weight of the stack directly to the building members without throwing any stresses on the boiler or its supports. The concrete outer shell is lined with 4 in. of heat-insulating brick and 13 in. of firebrick. Each of the brick linings is laid up independent of the other and of the concrete shell, not even an occasional tie being used to bind them all together. The brickwork is laid against a spherical surface molded on the inner face of the concrete when it was poured. The chord circle of the sphere is inclined with the vertical so that the top of the inside of the concrete wall leans away from the boiler. This gives a concave arched surface standing almost vertically, against which the brickwork of the lining tends to lean heavily, and the concave side of a spherical dome toward the fire. The brick linings are free to expand both horizontally and vertically, expansion joints being provided in the corners of the setting and at the top of the walls.

After nearly a year of hard service this setting shows almost no cracks in the concrete, and the brick walls, with the exception of the front wall over the stoker retorts, are in as good condition as when first put in. Trouble has been experienced in holding the front wall over the stoker retorts. This has been due to a faulty dust seal, which allowed dust to work down between the brick wall and the concrete wall, wedging the former out and overthrowing it into the fire.

In passing it may be noted that although this unit has been operated continuously except for cleaning periods at from 150 to 200 per cent. of rating, with occasional peaks as high as 300 per cent., the brickwork has not yet been hot enough to vitrify the high-temperature cement in which it was laid up. In fact, door liners cast from cement supposed to vitrify at 1600 deg. F. had to be discarded because there was not sufficient temperature to harden them and prevent their crumbling.

Two 406-hp. water-tube boilers, entirely independent of each other except for the steam, feed-water and equalizer connections between them, are hung from the steelwork of the building and from the unit now in operation. Being suspended independent of the setting, they are free to expand and contract without throwing any stresses into the brickwork or the concrete.

One of the points of interest in this installation is the 6-in. water-equalizer connection between the boilers, Fig. 6. This was intended to assist in keeping the water lines at the same height in the two boilers when both were fed from one feed valve. It has fully met this condition as it has maintained the water levels in the two boilers within two inches of each other when operating at 200 per cent. of rating, and with the feed shut off from both drums of one boiler.

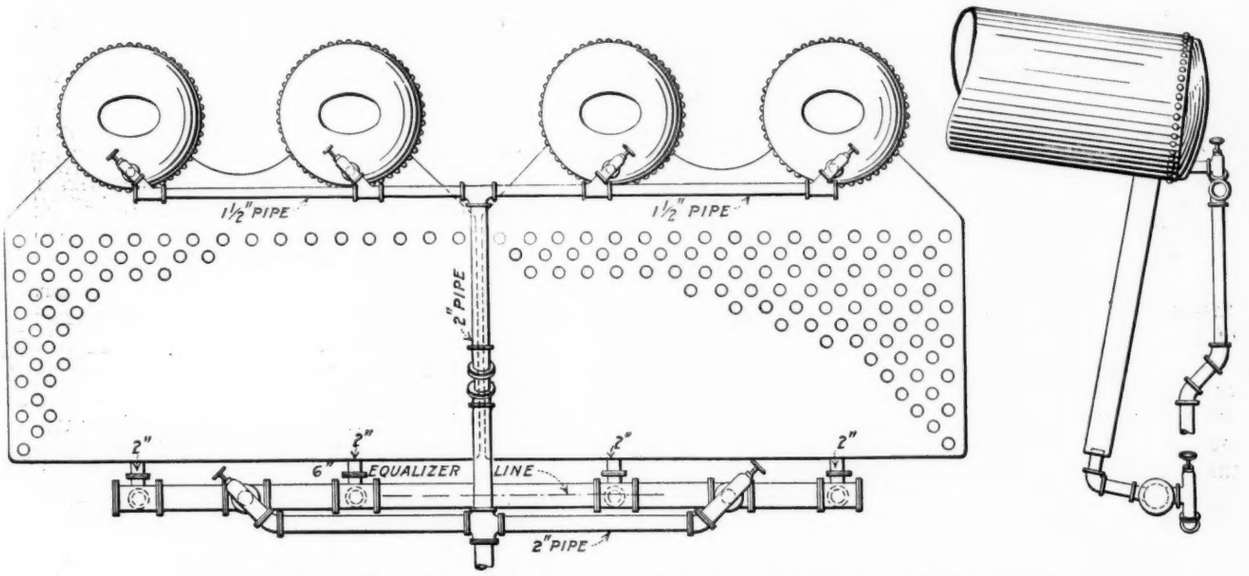

FIG. 6. THE SIX-INCH WATER-EQUALIZER CONNECTION BETWEEN THE BOILERS

Another point of interest is the inclination of the boiler tubes, which is 1½ in. per ft. instead of 1 in., the standard pitch of tube generally used with this type of boiler. The greater pitch was adopted because it was believed that under severe firing and sudden changes in steam demand a splitting or interruption of the circulation of the water in the lower rows of tubes might occur with the standard pitch. Two tubes recently removed from this boiler seem to confirm the soundness of this reasoning. They were bowed up away from the fire over seven inches in their length, thus indicating that the top of the tube had been at considerably higher temperature than the bottom, due doubtless to sluggish circulation caused by rapid formation of steam bubbles that accumulated at the top of the tube. It would appear that a tube pitch even greater than 1½ in. per ft. might be desirable to accelerate the circulation.

These boilers are horizontally baffled throughout with cast-iron baffle tile, which, contrary to prediction, does not warp, burn, crack or fall out. These tile were originally placed on the third row from the bottom, but have been removed recently to the fifth row to better equalize the gas velocities in the setting.

To facilitate the control of the operating conditions in the furnace, there are mounted on a control board, Fig. 7, convenient to the stoker-driving engine and in front of the boiler, a steam-flow meter, blast-pressure recorder, water-level recorder, steam-pressure recorder, illuminated-dial pressure gage, CO_2 recorder and a boiler-efficiency meter. These instruments provide the fireroom attendant with practically all the operating data required for the efficient operation of the unit. Hand-operated stack-damper control is provided for maintaining not over 0.05 in. water draft over the fire. As is frequently the case with hand-operated installations, this arrangement is not entirely successful, and

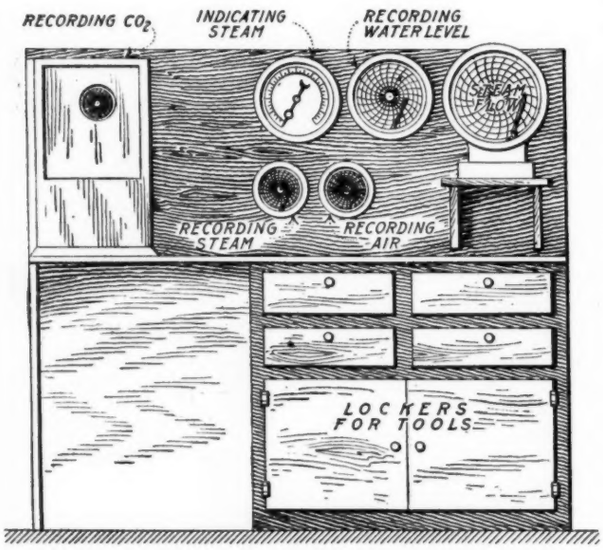

FIG. 7. CONTROL BOARD IN BOILER ROOM

automatic means for controlling the stack damper are under consideration.

The old boiler room was provided with a 2000-hp. open feed-water heater, a V-notch meter of 100,000 lb. per hour capacity, and a continuous water softener rated at 4000 gal. per hour, of the lime-and-soda type. This equipment treats, heats and meters the feed water, which is reduced to about two grains per gallon of hardness, and delivered to the boiler at a temperature of from 190 to 220 degrees.

Of the new unit the performance has been uniformly good. The superheat is quite constant, seldom varying 50 deg. from one day's end to another, and frequently running for days at a time with less than 10 deg. variation. Considering that there is no automatic means for regulating the superheat, but that the radiant energy of the fire and the amount of steam passing are the only controlling factors, this performance seems quite remarkable. The variation in the average superheat due to a change in load equal to 100 per cent. of the rating of the boiler causes little change in the superheat. In fact, this change in load could not be detected with certainty from the readings of the recording thermometer. Tests recently run on this unit at approximately 180 per cent. of the boiler rating showed a combined efficiency of 74.8 per cent. with coal of 9050 B.t.u. as fired, 14 per cent. moisture and 20 per cent. ash. The refuse produced in this test showed only 7 per cent. of combustible.

Recently, some very poor coal was received and burned at this plant. An analysis showed 16 per cent. moisture, 45 per cent. ash and a heat value of 4900 B.t.u. per lb. as fired. With this fuel the unit produced 950 boiler horsepower, 103 deg. superheat and showed a combined efficiency of about 80 per cent. These results were not obtained in a test, but were figured on the face of the flow-meter returns for 24 hours. This flow meter has been checked against weighed test results and has been found to be about 1 per cent. slow. A greater output could have been obtained with this fuel had it been possible to dispose of the ash as rapidly as it was formed, but the limitations imposed by the ash-handling end of the stoker, when called upon to handle nearly 300 per cent. more ash than it was designed for, limited the output to the figure given.

Economies figured on the basis of the flow-meter readings have run for 28 days at 70 per cent. or better combined efficiency. Sufficient tests have not been made, as yet, to determine at what output the maximum economy will be reached for this setting, but it seems likely that it lies near or beyond 200 per cent. of rating.

The labor required to operate this plant for 24 hours is three firemen and three helpers, or two men per shift. On one shift there are also one coal passer (crane man) and one car trimmer. This force is sufficient to handle all the coal required and the ashes produced by the unit. Indications are that no greater force will be necessary when the four units have been installed. The economies effected by the coal-handling apparatus alone on this unit approximate $1300 per month. When operating, the new unit displaces six 300-hp. boilers burning the same fuel in the old boiler room and has increased a two weeks' average evaporation by 0.9 lb. at the end of a second period of two weeks. The labor required for the old boiler room is nine firemen and six ashmen each 24 hours, from one to three coal passers and from six to 10 coal shovelers for 12 hours out of the 24.

The performance of the unit has justified the judgment on which the design was based. There remain, however, some details to be worked out before the mechanical operation will be entirely satisfactory. These details are of minor moment, wholly mechanical in nature, and present no unusual features.

From general reports France is poor in coal but not in water power. The best estimate places the hydroelectric resources of the country at five million primary horsepower and from four million to five million secondary, the first of these being available the year round and the second for six months of the year. Of this total only 750,000 horsepower had been developed in 1913. During the war, on the initiative of the government, 415,000 additional horsepower was developed, and other projects are now under way from which 125,000 hp. should be realized in 1919 and 225,000 hp. by 1921. This will carry the total water-power development to some 1,600,000 horsepower.

Production of gasoline from natural gas increased from 7 million gallons in 1911 to 104 million gallons in 1916.

Causes of Direct-Current Generators Failing To Build Up Their Voltage

By ROBIN BEACH

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Tells how a direct-current generator builds up its voltage, gives a number of causes why a machine may fail to come up to voltage and explains how to locate these faults.

THE two common types of direct-current generators now found in practical operation are shunt-excited machines and compound-excited machines. The latter may have the shunt field connected directly across the brushes—short shunt—as in Fig. 1, or connected across the armature and series field—long shunt—as in Fig. 2. When operating at no load, that is, with the generator switch open, a compound-wound generator is virtually a shunt-excited machine because the series fields do not function except under load conditions. Consequently, any discussion based on the no-load conditions of a shunt-wound generator will apply unconditionally to the compound-wound generator.

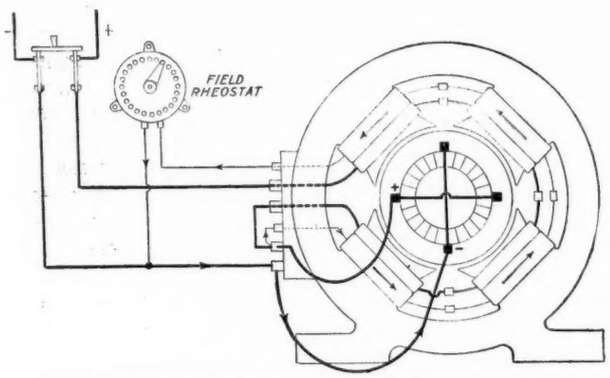


FIG. 1. COMPOUND-WOUND DIRECT-CURRENT GENERATOR CONNECTED SHORT-SHUNT

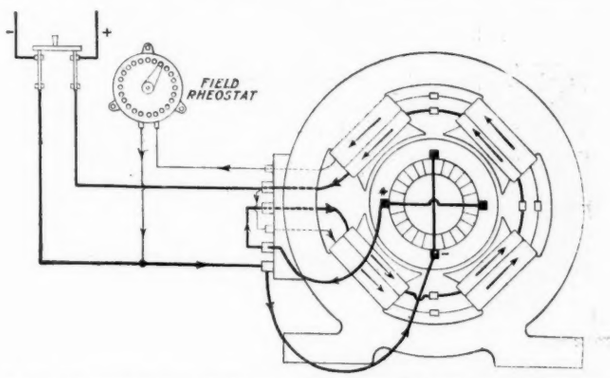


FIG. 2. COMPOUND-WOUND DIRECT-CURRENT GENERATOR CONNECTED LONG-SHUNT

The establishment of potential difference at the terminals of a generator is affected by virtue of the revolving conductors on the armature cutting the magnetic field of the polepieces. This voltage varies as the number of lines of force cut per second. That is, for a given value of magnetism, doubling the rotational speed of the armature will exactly double the voltage generated, or for a given constant speed the voltage generated will be doubled if the magnetic-field strength is doubled.

A direct-current generator is self-exciting only by virtue of the fact that the iron polepieces retain a certain amount of magnetism when the field coils are not carrying current, so that as the armature rotates and reaches normal speed, a small voltage is generated and becomes available at the terminals of the machine. This small potential impressed across the field coils will cause a small current to flow through the field circuit. The magnetism which is produced due to the magnetomotive force of this current through the field turns adds to that of the residual magnetism and more voltage is produced, which in turn sends more current through the field coils. This process of "building-up" voltage would increase indefinitely, but for the fact that the field flux does not increase indefinitely, as shown in the curve, Fig. 3. It will be seen from this curve that at first the volts increase very rapidly, but gradually reach a point where there is practically no charge. This zone is known as the point of saturation; that is, the iron in the magnetic circuit is magnetized to a strength where the flux cannot be increased. It is somewhere near the point of saturation that the voltage of a generator reaches its maximum value. Values below this are obtained by connecting an adjustable-resistance—field rheostat—in series with the field winding, as in Figs. 1 and 2.

If a shunt- or compound-wound machine fails to build up, the effect may be traced to one or more of several causes. Following are a number of causes why direct-current generators may fail to come up to voltage: (1) Loss of residual magnetism; (2) magnetomotive force produced by the field coils opposed to the residual magnetism of the polepieces; (3) external resistance connected in the field circuit too high (such as a rheostat all cut in); (4) brush-contact resistance unduly high because of dirt and grease accumulation; (5) poor fit of the brushes on the commutator; (6) vibration of machine due to unstable foundation, worn bearings, high commutator bars or high mica; (7) external circuit closed through a low resistance; (8) too low rotational speed; (9) open in the shunt-field circuit; (10) brushes off the neutral position; (11) loose connections of brush pigtails or armature circuit to the machine terminals.

1. The generator switch should in every case be open preliminary to the starting of the machine. When the generator is running at its normal rated speed, with the field circuit open, a voltmeter placed across the armature terminals should read a small voltage of the order of 5 to 15 or 20 volts, depending on the normal voltage of the machine. If a very low voltage or no voltage reading is obtained, the polepieces have lost their residual magnetism. The field coils must then be separately excited from another generator or from a battery source. If the machine is operating in parallel with another generator, the field can be excited the

proper polarity by opening the armature circuit and closing the switch, as on machine *A* in Fig. 4. In doing this care must be exercised to be sure that the armature circuit is open before closing the switch or the machine might be seriously damaged.

2. If the generator is operating at normal speed with the voltmeter across its terminals showing a residual voltage, but when the field circuit is closed this voltage is reduced, the current is then flowing through the field coils in the wrong direction so that their magnetomotive force bucks the residual magnetism. To remedy this condition the field terminals must be reversed.

3. The field-rheostat resistance should all be cut out of circuit when starting the generator so that the small residual voltage will send the largest possible current through the field windings.

4. Frequently, a machine will collect oil and dust particles to form a thin film under the brushes, so that when the residual voltage tends to send a current through the field coils the resistance at the brush contact surface is so high that the process of building up is rendered impossible. The commutator, brushes and brush-holders may be cleaned with gasoline.

5. Many times it is found that the brushes are making contact on only a limited portion of the surface,

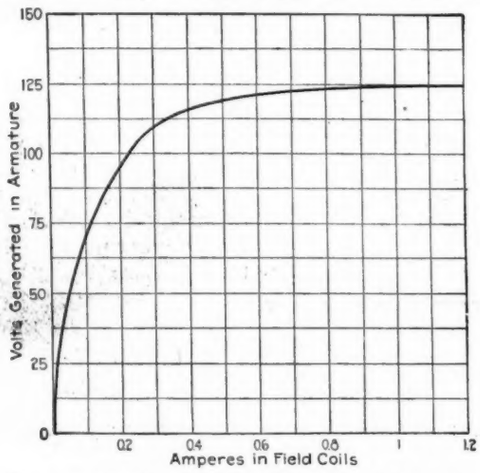


FIG. 3. VOLTAGE OR SATURATION CURVE OF A DIRECT-CURRENT GENERATOR

owing to a poor fit to the commutator, collection of dirt or to picking up copper particles from the commutator. In this case strips of sandpaper should be prepared a little wider than the brushes and a good fit procured by sandpapering each brush only in the direction of rotation, lifting it on the return.

6. Not infrequently is it found that the brush-contact resistance is made critically high because of vibration of the armature from one or more of various reasons. This mechanical difficulty may be observed and corrected if it is caused by the foundation or badly worn bearings. Sometimes the brushes are made to vibrate because of high commutator bars or mica-insulation projection. When this is the case the commutator must be turned down on a lathe or ground by using a stone. Pressing on the brushes will usually affect the voltage in case of vibration difficulties.

7. If the external circuit is left closed through a low resistance, the residual voltage at the terminals of the machine will not be maintained, because of the internal voltage drop in the armature, and the machine will not build up. The machine must always be disconnected from its load before starting.

8. When the speed is low, the voltage generated is proportionately low, which is substantially equivalent to an increased resistance in the shunt-field circuit. That is, a machine may build up with a given rheostat setting at a high speed; but when the speed is reduced it may not build up until the resistance is decreased below the critical value for this speed. The remedy is to get the machine up to normal speed.

9. An open-circuit in the shunt-field circuit may be located by connecting the field coils to a source of power

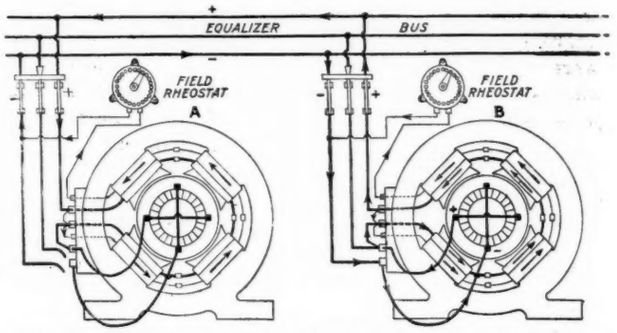


FIG. 4. EXCITING FIELD COILS WHEN TWO MACHINES ARE CONNECTED IN PARALLEL

and taking voltage reading across the coil terminals until the open-circuit is found, as in Fig. 5. The voltmeter will read practically full voltage when connected across the terminals of the defective coil. A lamp may be used for the same purpose, and will light up when connected across the defective coil's terminals; its brilliancy will depend upon the resistance of the coils.

10. When the brushes are moved off the neutral position, the voltage available at the machine terminals is less than when the brushes are located on the neutral. The farther off the neutral they are the less the voltage will be until at 90 electrical degrees the voltage is zero. The brushes should be set on the commutator where the maximum voltage occurs.

11. Sometimes when the foregoing remedies do not clear the trouble, it may be traced to poor connections

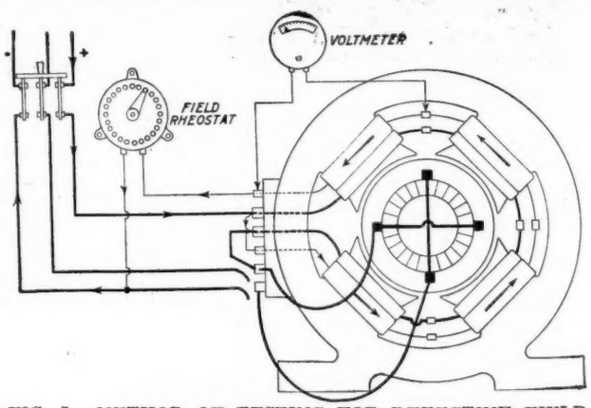


FIG. 5. METHOD OF TESTING FOR DEFECTIVE FIELD COILS WITH A VOLTMETER

in the brush circuits due to brush pigtails loosening or to faulty connection to rocker-arm studs.

An attempt to separately excite the machine at the early stage of the investigation will very often eliminate many of the foregoing factors at once and make the solution quite simple.

Very recently, the author was called upon to investigate the failure of a machine to build up. It was a

1400 r.p.m. Speeds above 700 r.p.m. are obtained by 600-ampere 6-volt machine for electrolytic purposes. The difficulties found were: First, the machine vibrated badly because of poor foundation; second, the brushes were considerably off neutral; third, the brush fit was very poor. After remedying these defects, the machine came up to voltage; however, as soon as a load of 15 amperes was put on it, the voltage immediately fell to zero. The series fields were reversed, but the same thing happened. The brushes were moved to observe the effect on the voltage, but this did not improve matters. It was finally concluded that a very large drop occurred at the brush-contact surface. This was taken up with the company from whom the machine was purchased, and it was found that through an error carbon brushes had been sent out with it. The substitution of metal-graphite brushes immediately solved the whole problem. For carbon brushes a drop of two volts is a fair average per set of brushes while for metal-graphite it is only about 0.2 volt. Brush-contact drop is a point of vital concern on a low-voltage machine.

Reliance Automatic Coal Scale

A coal scale for power-plant use has been developed recently by the James A. Brady Foundry Co., of Chicago. It is known as the Reliance automatic coal scale and for continuous weighing is claimed to be accurate within one per cent. Coal comes to the scale from the overhead bunker through a pipe that is attached to a casting forming a part of the scale frame. This casting stands about five inches above a horizontal circular rotating disk which supports the coal in the form of a conical pile (see Fig. 1). Above the disk there is a stationary casting which serves to scrape off a certain amount of coal as the disk is revolved on its axis by a motor or through a belt connection to a lineshaft. From the disk the coal falls into a cast-iron weigh hopper having vertical sides and rounded corners, as shown.

As the unit weighment is approximated, the balanced scale beam begins to tip down. The first part of this motion throws out the clutch driving the speed disk and stops the discharge of coal into the hopper. A sliding weight serves to compensate for the amount of coal momentarily in suspension and makes the net weight of coal actually delivered to the hopper the exact amount desired. The second part of the downward travel of the weigh hopper trips the balanced gate serving as a hopper bottom, and the coal is all dumped out. When the last piece of coal clears the hopper bottom, the weigh hopper starts to return to its original position. The slightly overbalanced bottom first closes, and then the driving clutch is thrown in and the coal feed is resumed. It is possible to adjust the compensating weight at the second trial weighment, and when this is once adjusted the scale will continue to operate accurately as long as coal is delivered to it.

Should the chute or hopper below the scale become filled, the weigh hopper will not completely discharge and the hopper bottom will remain open as long as there is any coal resting on it. As the fireman removes the coal from the bottom of the chute, the coal will gradually work out of the hopper and when the last particle is out, the bottom will close as previously described. It takes about ten seconds for a dump to be made, so that it is readily possible to make 100 weighments an hour, including the filling of the hopper. In ordinary operation the number of weighments will depend upon the rate of feed to the stokers, and this is automatically controlled as previously described.

The scale is all cast-iron construction and has a straight-sided hopper. Hardened-steel knife-edges are housed in a cast-iron box with a felt washer so placed as to exclude the dust from the coal. From the illustrations it will be apparent that the apparatus has a heavy frame of box section to prevent distortion of the weighing element should the scale happen to be unevenly supported. To reduce the amount of counterweight necessary and lighten the stress on the wearing parts, the ratio of the two arms of the balanced lever is four to one. The operating shaft is inclosed in a dustproof case and it is carried in ball bearings. Upon request a set of flanged wheels are attached to the scale frame, making it possible to roll the scale out from under the coal chute should it be desired to use it in more than one locality. An automatic counter is furnished with each scale, and this may be attached directly to the frame, as shown in Fig. 3, or it may be located on the boiler-room wall where it can be seen easily and read by the boiler attendant.

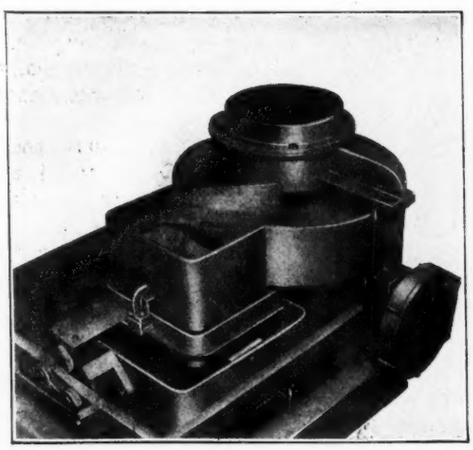


FIG. 1. SCALE SHOWING ROTATING DISK, SCRAPER AND TOP OF WEIGH HOPPER

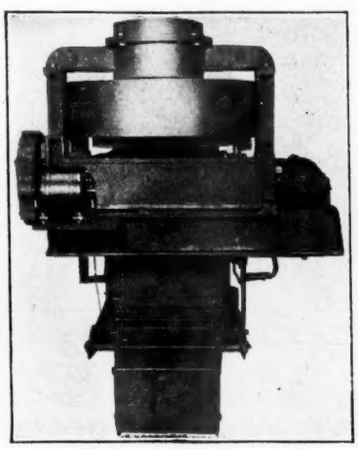


FIG. 2. FRONT VIEW OF SCALE SHOWING DRIVING GEARS AND MOTOR

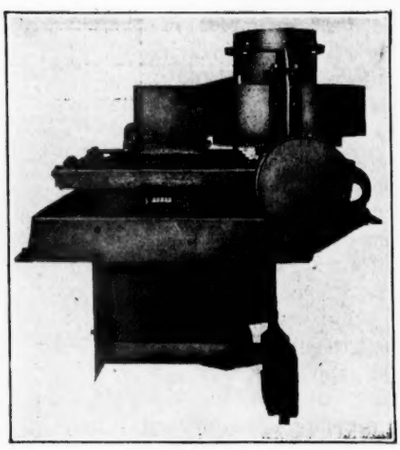
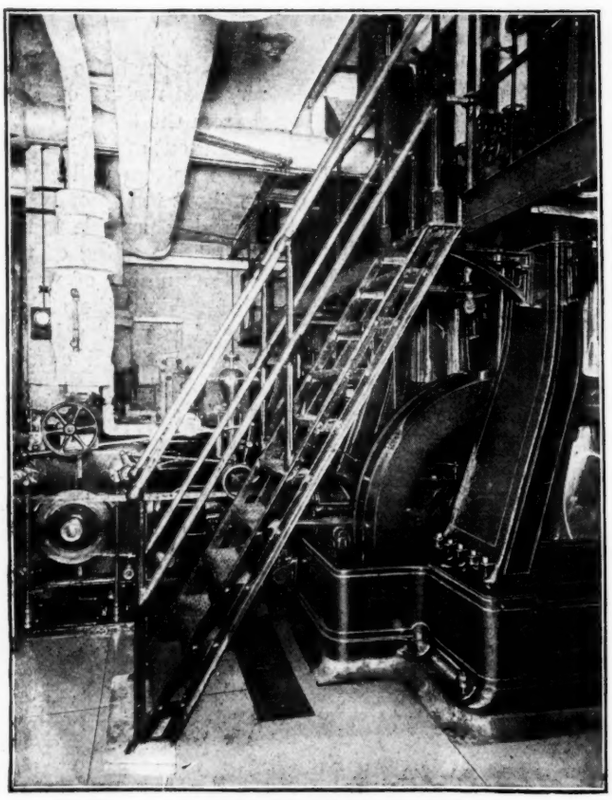


FIG. 3. SIDE VIEW OF SCALE SHOWING HOPPER BOTTOM AND COUNTER

Furnish the finish—the Victory Liberty Loan.

Refrigerating Equipment of the Pennsylvania Hotel



A FEW years ago the story of making artificial ice sounded to the layman very much like a tale by Jules Verne or some other equally great romancer in natural laws. Yet today artificial ice and refrigeration have become such important factors in our existence as to rank with sanitation, pure-water supply, etc., and are accepted in the same commonplace way as all other necessities for human existence. Probably one of the best examples of the importance of artificial refrigeration is found in a modern hostelry such as the Hotel Pennsylvania, New York City. One has only to consider that if the total capacity of the refrigeration plant in this hotel was utilized for ice making, 100 tons of ice could be produced every 24 hours, sufficient to supply a city of 50,000 population with ice for family use. As pointed out in the article, "Mechanical Equipment of a Modern Hotel," in the Feb. 18, issue, the decision on how the power-plant equipment should be driven was made only after a very careful study of the hotel's exhaust-steam requirements, by the consulting engineers, Messrs. Tenny and Ohmes, on heating, ventilating and refrigerating equipment, and by Charles E. Knox on the electrical equipment, for the architects, McKim, Mead & White. As a result of these investigations it was found that the refrigeration machinery could be most economically driven by steam engines, since all the exhaust steam can be used through the year for heating and cooking purposes.

The refrigeration machines are three in number, each having a capacity of 65 tons of refrigeration at normal speed. Each unit consists of two vertical single-acting ammonia compressors directly connected to each end of the crankshaft of a horizontal Corliss engine (see headpiece) operating on a steam pressure of 150 lb. per sq.in. The condenser is of the double-pipe countercurrent type, having a capacity of 200 tons. Two receivers are used, each 20 in. diameter by 15 ft. long, built of steel, with welded heads tested to a hydrostatic pressure of 500 lb. per square inch. There are three brine coolers—one for the low-pressure brine system, one for the high-pressure brine system and one for the ice-cream freezers—having a total of 14 sections. The coolers are of the double-pipe countercurrent type, each section being 10 pipes high by 20 ft. long, made up of 1½ in. x 2½-in. pipe. For circulating the brine there are six pumps, three steam-driven end-packed plunger type and three motor-driven centrifugal pumps. The high-pressure centrifugal pump is provided with a cast-steel casing that will withstand a static-head pressure of 500 ft. All the centrifugal pumps run at a maximum of

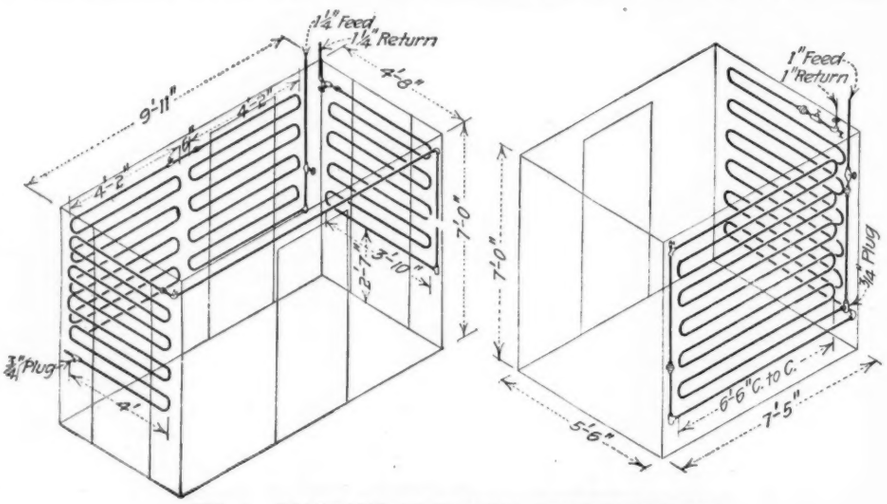


FIG. 1. DIAGRAMS OF TYPICAL REFRIGERATORS

1400 r.p.m. Speeds above 700 r.p.m. are obtained by shunt-field control of the motors.

The plunger pumps are full brass fitted, with brass-lined water cylinders, seat valves and water pistons and bronze piston rods. The centrifugal pumps have bronze impellers mounted on bronze-covered steel shafts.

There are approximately 100 refrigerating boxes throughout the building, totaling 35,000 cu.ft. contents. They contain coils, made up of 1¼-in. extra-strong galvanized pipe, sufficient to maintain the specified temperature in the boxes. Typical refrigerators are shown in Fig. 1. The ice-cream boxes are designed to maintain a temperature of 10 deg. F.; others are for temperatures suitable for the material they are to contain. The pastry cooks' refrigerator, for example, does not require a temperature lower than 50 or 40 deg. F. Brine is the cooling medium for these boxes (no ammonia is used above the basement), and it is circulated in three systems of piping: The high-pressure, for all parts of the building above the first floor; the low-pressure, for the first floor and below, including the 20 x 34-ft. ice-skating rink in the basement grillroom; and the ice-cream system, for all boxes requiring 20 deg. F. or lower temparature. Each system has duplicate circulating pumps; one is steam- and the other electrically driven.

The ice-making equipment is comparatively small, as the demand for ice is limited to a few special uses in dining rooms, etc. The freezing tank is approximately 55 ft. long, 12 ft. wide and 4 ft. deep and will take 200 cans of 300 lb. each. It is fitted with 800 lin.ft. of 1¼-in. direct-expansion ammonia coils. An electric traveling crane over the freezing tanks handles two

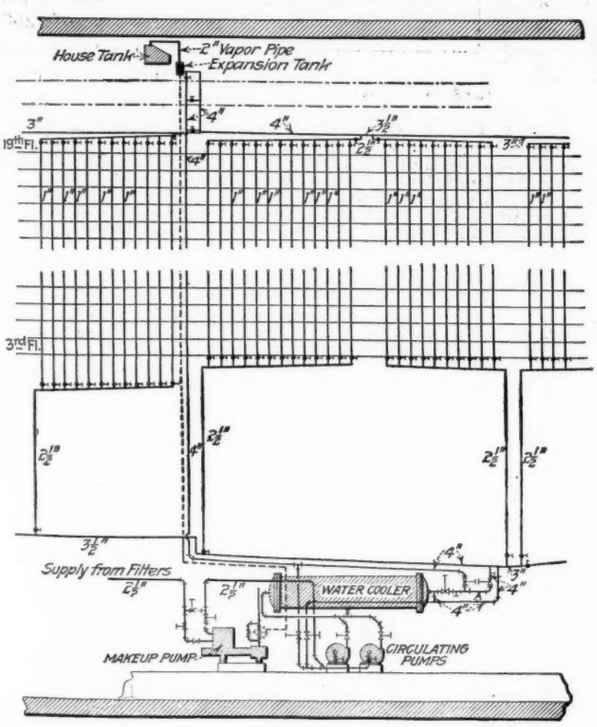


FIG. 2. DRINKING-WATER COOLING SYSTEM

cans of ice at once, conveying them to the "hot well" for thawing the ice free from the cans. The water in the hot well is kept hot by submerged steam pipes, and two cans of ice may be lowered into it at once, but none of the hot water comes into contact with the ice. The cans are then carried by the crane to the "can dump," from which the ice is delivered by gravity to the storage room.

Air agitation for the water in the ice cans is supplied by a motor-driven compressor. The air is taken from the fresh-air duct of the engine room and piped through the ice-storage room, where it is chilled before

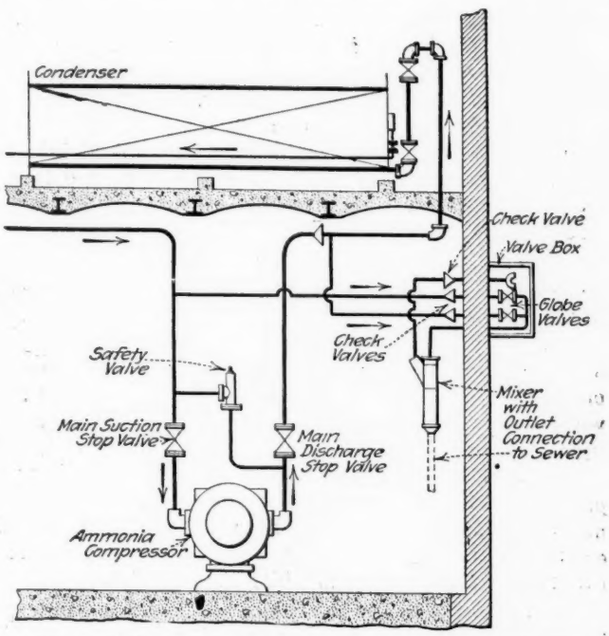


FIG. 3. ARRANGEMENT OF SAFETY CONNECTIONS

entering the compressor so that it is delivered to the ice cans nearly moisture free and in a condition to secure the maximum amount of clear ice. The water for ice making is first passed through a primary and a secondary set of filters of 24 units each, thence to the ice-making water-supply tank, where it is precooled to 40 deg. by a direct-expansion ammonia coil before being delivered to the freezing cans. A motor-driven centrifugal pump is used to agitate the brine in the freezing tank.

An ice-cutting room is located near the storage room, in which there are two "cubers" and two crushers. One of the cubers has a cutting capacity of 6000 1½-in. and the other 5000 2-in. cubes per hour. The crushers have an hourly capacity of five tons each.

The drinking water is first passed through filters, then cooled to 40 deg. F. in a circular galvanized-iron tank containing 1580 lin.ft. of 2-in. direct-expansion ammonia pipe coils. These coils are helical and four in number, each independent of the other, with outside connections to the ammonia system, so that any or all may be put into service as desired. Fig. 2 shows the pressure drinking-water cooling tank in the basement, with pipe sizes indicated, a typical set of risers, and the expansion tank at the top of the building. It will be seen by tracing the piping to and from the circulating pumps that the water may be fed through the cooling tank into the risers and returned through a common return pipe from the expansion tank, or it may be discharged through the cooling tank to the expansion tank, thence downward through the service pipes as may be desired. The service pipes supply approximately 2300 taps with water at about 40 deg. F. This piping is arranged in groups above the third floor as shown and valved top and bottom so that any riser may be shut

off independently, or the whole section may be shut off at the main valves.

A safety valve is connected between the ammonia discharge or compression piping, near each compressor, and the low-pressure or suction piping, to relieve the system of overpressure. Also there is an arrangement of piping for discharging all the ammonia under pressure into a mixer, where sufficient water may be added to absorb all the gas and carry it off to the sewer. This piping is extended to an emergency valve located outside of the building at the sidewalk, as shown in Fig. 3, and provided with a standard fire department siamese so that the ammonia system may be emptied into the sewer from this point by a fireman or police officer in case of emergency, as is required by the New York City regulations.

(An article describing the electrical and elevator equipment in this hotel will appear in an early issue.)

Electrical Recording of Boiler-Heat Losses

BY JOHN B. C. KERSHAW

An interesting type of instrument for measuring and recording the heat losses in chimney gases, depending upon a new principle, has been devised by a French chemist, M. Chopin, and was described before a recent meeting of the *"Academie des Sciences."*

The working of the instrument is based on the measurement of two electric currents, the intensity of the one being dependent upon and varying with the temperature of the waste gases, and the intensity of the other being dependent upon and varying with the percentage of CO_2 contained in the same gases.

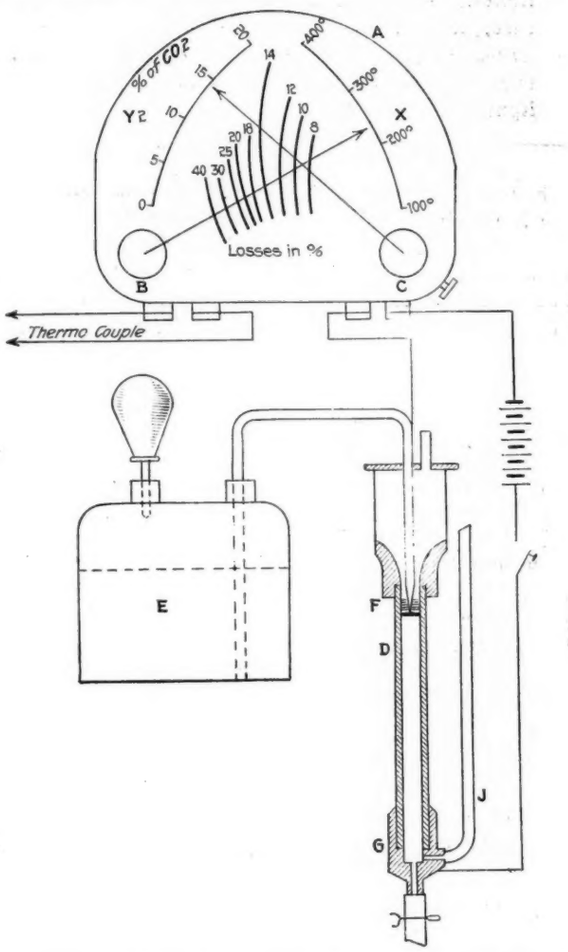
The first measurement is obtained by means of an ordinary thermocouple placed in the path of the gases, and the second is obtained by measuring the electrical resistance of a solution of caustic soda of known strength and volume, through which a definite volume of the chimney gases is passed. The absorption of CO_2 by the caustic soda and the formation of sodium carbonate cause an increase in the electrical resistance and therefore a diminution in the current that can be passed through the solution with a constant electromotive force, for the conductivity of sodium carbonate in solution is only one-third that of caustic-soda solutions.

The most striking and original feature of the instrument, however, is that by which the results of the two measurements are automatically converted into percentage heat losses, which can thus be read off by the engineer or fireman in charge of the boilers, without any necessity for complicated or involved calculations.

The arrangement of the apparatus and mechanism is shown diagrammatically in the illustration, where *A* is the indicating dial, *B* is the indicating finger that records the temperature of the gases on the scale marked *X*, by means of the thermocouple shown below it, and *C* is the indicating finger that records the percentage by volume of CO_2 in the waste gases, on the scale marked *Y* by means of the electrical-resistance measurement of the solution contained in the vessel *D*.

The point where these two indicating fingers cross each other on the recording dial gives the percentage of heat losses, since the curved lines represent the results of calculations for the other fixed factors that enter into the equation.

As regards the other parts of the apparatus, *E* is the vessel in which the caustic-soda solution is prepared and stored before use; *J* is the pipe by means of which the waste gases are conducted into the mixing tube or burette *D*, which serves not only to measure the volume of chimney gas, but also to give a definite volume and length of electrolyte between the nickel electrodes at *F* and *G*. After each test the solution of caustic soda,



INSTRUMENT FOR RECORDING LOSSES IN CHIMNEY GASES

containing more or less carbonate, is run off from the bottom of the absorbing and measuring burette. A fresh volume of gas is then admitted, and this is treated with the caustic-soda solution, pumped over from the vessel *E* by aid of a hand pump.

It is reported that the Missouri Senate Committee on Judiciary recently submitted a favorable report on a bill introduced by Senator Gardner, of St. Louis County, giving the State Public Service Commission the power to regulate rates for electricity generated outside of the state and sold in Missouri. The object of the bill is to regulate the rates of the Keokuk Plant, on the Mississippi River, from which St. Louis and other cities in the eastern part of the state obtain a large amount of electric energy.

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Combustion of Lignites and High-Moisture Fuels

By T. A. MARSH
Chief Engineer, Green Engineering Company, East Chicago, Ind.

Types of stoker adaptable to the burning of lignites containing as high as 35 per cent. moisture, at efficiencies approximating 70 per cent. Pre-drying is considered impractical. The drying must be done in the furnace in which the lignite is burned.

AMONG the lowest grades of fuel with which combustion engineers must work are the lignites and high-moisture coals. Many of these fuels contain more than 40 per cent. of moisture and less than 6000 B.t.u. per pound when mined. From such fuel it is evident that even after obtaining satisfactory

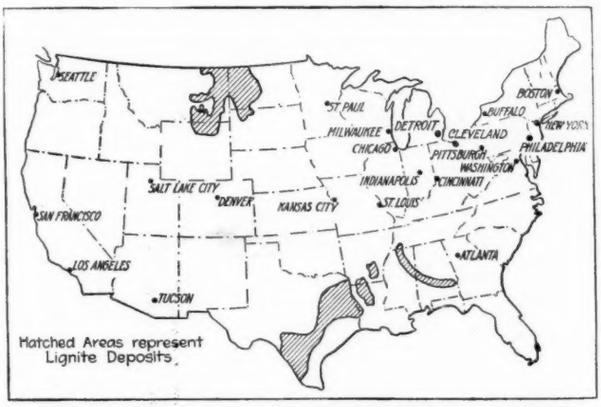


FIG. 1. LIGNITE AREAS OF THE UNITED STATES

combustion, the net heat delivered to the boiler is small, due to the low initial heat value and the loss due to evaporation of the moisture in the coal. The problem has presented such difficulties that there is a prevalent opinion that lignites cannot be burned successfully. It is the purpose of this article to describe methods of burning these fuels and to give results obtained in their combustion.

The lignite deposits of North America occur in five main areas: North Territory and Alaska, Alberta and Saskatchewan, North Dakota and Montana (Fort Union region), Texas region, Mississippi and Southern Alabama (Mississippi River). The lignite areas of the United States are indicated on the map, Fig. 1. There are areas in Wyoming and Colorado containing high-moisture coals, 20 to 30 per cent., that will be discussed also in this article.

Lignites contain on the average from 20 to 40 per cent. of moisture when mined. These fuels have a spongy structure and woody fiber. They slack on the surface within a few hours when exposed, the action being similar to that of lime. Unfortunately, the drying process does not penetrate deeply into the pile, but is a surface action. On account of the high percentage of moisture and the slacking property of lignite, it cannot be transported successfully far from the mine, so that the development of this fuel has been limited.

Combustion of high-moisture fuels divides itself into two distinct processes—the drying of the fuel and the burning of the dry fuel. There are two methods of approaching the problem—by pre-drying the fuel before it enters the furnace or drying it in the furnace.

Pre-drying lignite at the rates desired in most plants is prohibitive both on account of the apparatus involved and on account of the cost of coal for the process. Unless, therefore, some waste-heat method of pre-drying is developed, there is little to be hoped for along this line.

All furnaces that successfully burn lignite have in them elements designed to dry the fuel, preparing it for the later stages of combustion. Evaporation can occur only from the surface, as the fuel burns, leaving exposed more moist fuel below to dry and burn. Complete combustion of all the lignite necessitates thin fuel beds. Everyone having experience with lignites is familiar with this fact. With hand firing it is difficult to keep the fire thin enough and at the same time free from holes.

Two types of stoker are producing excellent results—the plain chain grate and the "L" type chain grate with inclined coking plates. On a chain grate the volatile gases burn off rapidly after the fuel is dry, leaving a bed of fuel burning with little flame, similar to charcoal. This burns out to a fine, light, white ash.

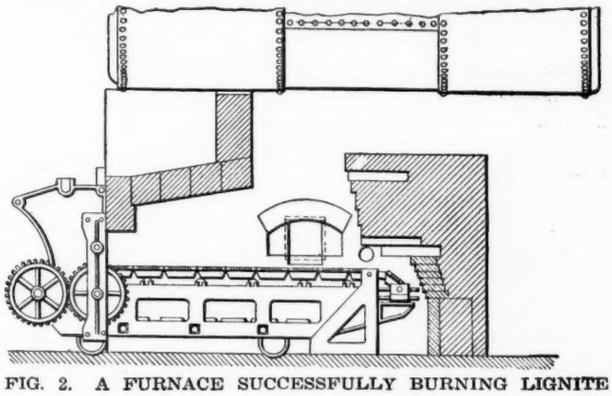


FIG. 2. A FURNACE SUCCESSFULLY BURNING LIGNITE

The "L" type chain grate with inclined coking plates at the front has produced excellent results with lignites. The coking plates tip up the front part of the fuel bed at an angle to the hotter portion of the fire, and ignition is thereby intensified. The incline serves as a drying region and the stirring action obtained by the fuel cascading over the coking plates serves to expose practically all surfaces of the fuel to the drying action of the furnace temperatures. The fuel, therefore, reaches the grate ignited and ready for rapid combustion.

With these fuels extremely high draft is not essential for high combustion rates, as it is possible to burn liberal amounts of "coal as fired" per square foot of grate with moderate draft. Table I gives rough estimates of the relation of draft in the furnace to the combustion rates of coal as fired.

In all calculations of draft involving areas of boiler

passes, flues and chimneys, allowance must be made for the high rate of coal per horsepower with these fuels. For instance, 6.6 lb. of Malakoff lignite containing 7124 B.t.u. and burned at 71.3 per cent. efficiency is required per horsepower developed. All calculations should therefore be made on pounds of coal and not on any predetermined table or rules based on horsepower developed.

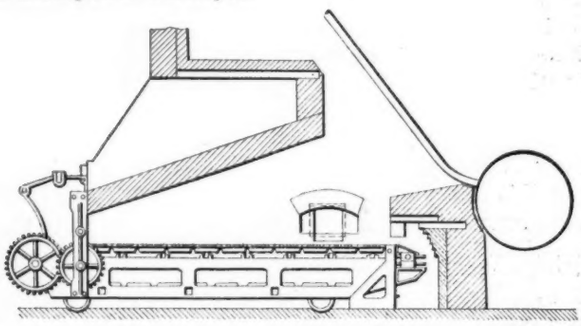


FIG. 3. FURNACE FOR BURNING LIGNITE UNDER THE STIRLING TYPE BOILER

It is only within the last five years that furnaces have been developed to successfully burn these fuels. So little has been said regarding this development that the results obtained are not common knowledge. A typical analysis of North Dakota lignite is given in Table II. On account of the high moisture content, no successful commercial method has been found for burning this fuel. There are, therefore, large areas of this lignite waiting on the further development of

TABLE I. FURNACE DRAFT FOR VARIOUS RATES OF COMBUSTION

Coal as Fired per Sq. Ft. of Grate Area, per Hr., Lb.	Furnace Draft In. of Water
10	0.06
20	0.15
30	0.25
40	0.37

the art of combustion. That part of this field which extends beyond the Canadian border, however, bears lignites sufficiently low in moisture to permit of successful combustion. It is called "Souris lignite" and a typical analysis is given in Table III.

This fuel is being burned on chain grates in many plants with success. Large grate areas are, of course, necessary; usually at least one square foot of grate

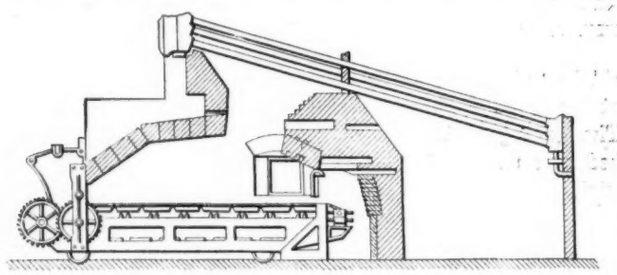


FIG. 4. FURNACE FOR BURNING THE SOUTHWESTERN LIGNITES

for each 30 sq.ft. of steam-making surface. A type of furnace successfully burning this fuel is shown in Fig. 2. The elements required in this furnace are a liberal igniting arch and a vertical bridge-wall or preferably an arch at the rear, reflecting the heat forward and deflecting the gases forward over the fuel. Such a furnace will ignite and burn 30 lb. of the lignite in Table III per square foot of grate area per hour.

The lignites of Colorado do not contain as high a percentage of moisture, 30 per cent. being about the maximum. Pike View lignite of the analysis given in Table IV is typical. Danville lignite contains a higher percentage of ash and slightly lower moisture than Pike View. Both are found in the Colorado Springs district.

Several years ago furnaces were developed that would burn these fuels at good combustion rates. The figures in Table V give results obtained eight years ago on

TABLE II. TYPICAL ANALYSIS OF NORTH DAKOTA LIGNITE

Moisture, per cent	41
Volatile, per cent	24
Fixed carbon, per cent	27
Ash, per cent	8
B.t.u., commercial	6,241
B.t.u., dry basis	11,932

chain grates from Pike View lignite. Results from modern furnaces would appreciably surpass these figures.

A number of plants are using this fuel. A typical installation in connection with a Stirling boiler is shown in Fig. 3. This setting is giving high combustion rates and high efficiencies from these high-moisture fuels.

In Texas the vast lignite fields are practically undeveloped. In this section of the country lignite must

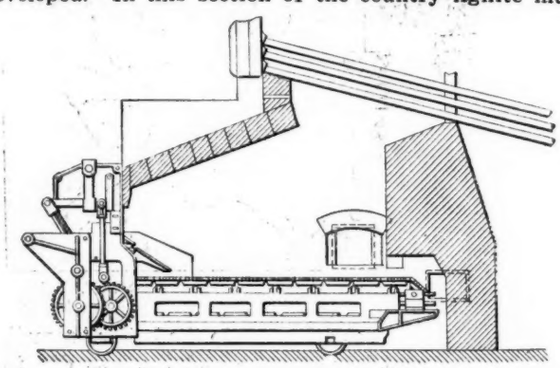


FIG. 5. THE STOKER HAS INCLINED COKING PLATES

compete with coals of Texas, as well as those of Arkansas, Oklahoma and New Mexico. In addition oil and natural gas offer cheap fuels, so that the development of furnaces for burning lignite naturally has been retarded. Many of these lignites have been burned with

TABLE III. TYPICAL ANALYSIS OF SOURIS LIGNITE

Moisture, per cent	29.7
Volatile, per cent	30.3
Fixed carbon, per cent	31.0
Ash, per cent	9.0
B.t.u., commercial basis	7,571
B.t.u., dry basis	10,770

excellent results on chain grates. A design of furnace developed for these fuels is shown in Fig. 4. In addition to the ignition arch there is a reversed arch from the bridge-wall, bringing the heat forward over the fuel bed. This construction is to be recommended for the combustion of lignites. An analysis of the fuel

TABLE IV. ANALYSIS OF PIKE VIEW LIGNITE

Moisture, per cent	23.73
Volatile, per cent	35.25
Fixed carbon, per cent	33.23
Ash, per cent	7.79
B.t.u., commercial basis	8,511
B.t.u., dry basis	11,160

burned and some typical results with this furnace are given in Table VI.

Some interesting results have been obtained with the coking type "L" chain grate, shown in Fig. 5.

In addition to the usual horizontal chain-grate surface, it has an inclined coking plate approximately 3 ft. long. When burning lignites, this inclined surface serves as an excellent drying zone. Tipped up as it is, at an angle to the hotter portion of the fire at the rear, the drying progresses rapidly, so that by the time the fuel has reached the horizontal chain surface, the moisture has been driven off and the fuel has become thoroughly ignited. Results from this furnace burning Calvert (Tex.) lignite, are given in Table VII.

TABLE V. RESULTS OBTAINED EIGHT YEARS AGO FROM PIKE VIEW LIGNITE

Type of stoker	Green chain grate
Type of boiler	B. & W.
Coal per sq.ft. per hr., lb	28
Furnace draft, in. of water	0.23
COe at damper, per cent	12
Per cent. of rating developed	128
Combined efficiency, per cent	69.7

Considering the high percentages of moisture (24 to 30 per cent. in the fuels previously discussed) efficiencies of 67 to 72 per cent. are creditable, it being impossible to develop the high efficiencies obtained from low-moisture fuels. Such fuels as Calvert lignitc with 30 per cent. moisture require 372 B.t.u. per pound simply to evaporate the moisture that is in the fuel and heat the resultant steam to a temperature oi 500 deg. F., assuming a temperature of 80 deg. F. in the boiler room. The heat thus used is 5 per cent. of the total heat in the fuel as fired, and must detract directly from the efficiency of steam generation.

TABLE VI. RESULTS FROM SPECIAL FURNACE DESIGNED FOR BURNING LIGNITES

	Malakoff	Treadlew
Moisture, per cent	29.93	29.80
Volatile, per cent	30.96	31.34
Fixed carbon, per cent	25.46	23.71
Ash, per cent	11.66	13.15
B.t.u., commercial	7,124	6,906
B.t.u., dry basis	10,314	9,838
Type of stoker	Green chain grate	Green chain grate
Type of boiler	B. & W.	B. & W.
CO_2 at damper	11.81	12.2
Coal per sq.ft. per hr., lb	30.6	31.6
Draft in furnace, in	0.32	0.24
Combined efficiency, per cent	71.3	69

TABLE VII. RESULTS FROM "L" TYPE CHAIN GRATE BURNING CALVERT LIGNITE

Name of fuel	Calvert (Tex.) Lignite
Moisture, per cent	30.17
Volatile, per cent	38.33
Fixed carbon, per cent	24.03
Ash, per cent	7.48
B.t.u., commercial basis	7,462
B.t.u. dry basis	10,669
Kind of boiler	Babcock & Wilcox
Kind of stoker	Green "L" type chain grate
Coal per sq.ft. of grate per hr., lb	36.4
Furnace draft, in	0.34
CO_2 at damper	11.2
Combined efficiency, per cent	67

With established results averaging about 70 per cent., and with many plants successfully burning lignites containing as high as 35 per cent. moisture and only 6800 B.t.u., plant owners, engineers and designers in localities where these fuels are involved can, with assurance, base calculations and designs on the use of lignites.

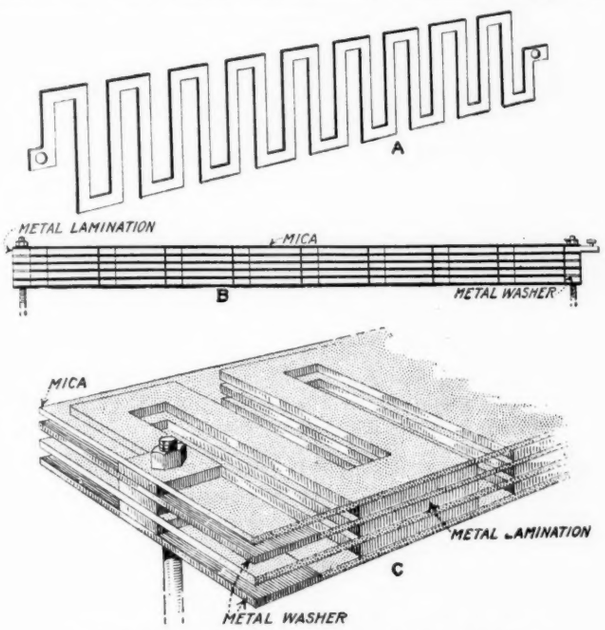
It is anticipated that construction work will begin in the course of a few weeks on the dam of the Georgia-Alabama Power Co. on the Flint River, about two miles above Albany, Ga. A concrete dam will be placed in the river at Porter Shoals and work will be under way by early summer. With the damming of the river, something like 12,000 additional horsepower will be made available to meet the increasing demand for electric energy.

Trouble Caused by Faulty Construction

BY E. C. PARHAM

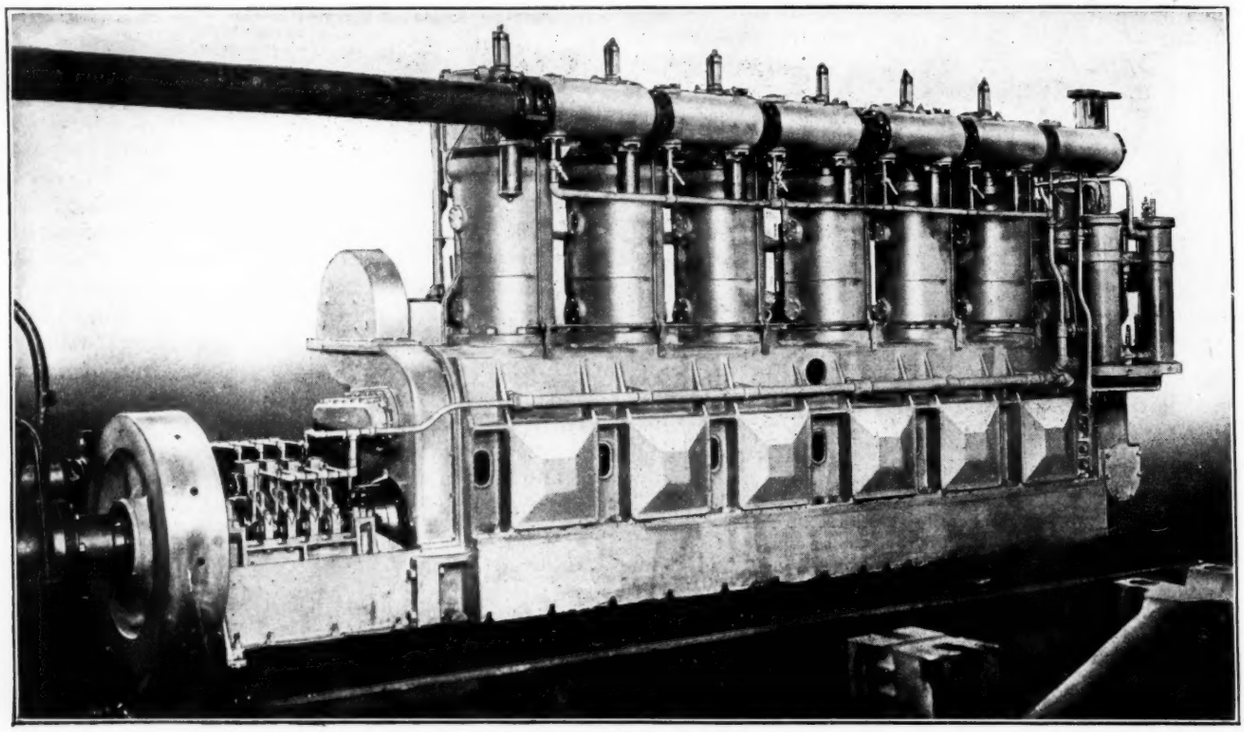
Diagram *A* in the figure shows one of the iron laminations used as the unit resistance element of a certain type of starting rheostat. Due to the slots punched in the sides, a current entering at one end must take a zigzag path to the other end, thereby traversing a considerable length of metal. In the building of a complete rheostat these elements are assembled alternately with thin unslotted strips of mica so placed as to insulate the punchings from each other excepting at alternate ends as shown at *B*. It is evident that with this construction a current entering at one end of a completed rheostat must traverse the full length of all laminations in order to reach the other end of the rheostat. An enlarged view of the assembly is given at *C*.

A number of motors were giving trouble by blowing the fuses when started. When the motors were first installed they started satisfactorily, but after being in service for a short time they began to act as if the starter did not have sufficient resistance, and frequently the fuses would blow owing to the inrush of current when the starter was placed on the first point. It was finally decided to take one of the resistances apart.



CONSTRUCTION DETAILS OF GRID RHEOSTAT

Factory-made resistance laminations are generally rolled after being punched in order to remove the burrs due to the punching operation. The laminations in the starters in question had the appearance of having been sawed and they certainly had never been rolled, because the slots had burrs the length of which very much exceeded the thickness of the mica separators. The result was that even the normal pressure incident to firm asembly was sufficient to force some of the projecting burrs through the intervening mica, and this condition became aggravated when heat due to usage caused the laminations to expand and buckle. After dismantling each resistance and cleaning the burrs from the laminations and assembling again, no more trouble was experienced.



McIntosh & Seymour Marine Diesel Engine

Some of the details of a four-stroke-cycle Diesel engine for marine service. It is directly reversible and uses no reversing gear between the engine shaft and the propeller shaft.

INCREASED production of marine Diesel engines both at home and abroad has been one of the interesting developments of the war. A typical modern engine of this class is that built by the McIntosh & Seymour Corporation, views of the opposite sides of which are shown in the headpiece and Fig. 1. It is of six-cylinder construction and develops 500 hp. at 185 r.p.m. Each cylinder has a bore of 16 in. and a stroke of 24 in. and the engine works on the four-stroke cycle.

The cast-iron bedplate is of the box type and is strongly reinforced with vertical ribs. The bottom forms an oil pan that slopes toward the rear end and receives the oil drippings from the bearings and cranks. On the bedplate is bolted the frame, which is cast in one piece, vertical ribs being provided in place of throughbolts to take up the working stresses. The elimination of throughbolts allows a narrower frame to be used.

Large openings at the side of the frame afford access to the cranks; these openings are fitted with sheet-steel doors of much lighter weight than the usual cast-iron covers, which reduces the labor of removal for inspection. Between the doors are small ports that enable the bearings to be observed while the engine is in operation, as well as assist in maintaining the frame at a low temperature by permitting a breathing action.

The main bearings follow the lines of those employed on the McIntosh & Seymour stationary Diesel, being of two-piece construction, and lined with white metal. Unlike the stationary engine, no oil well is used, since the oiling is accomplished by stream lubrication. The oil after passing through the bearing drips to the bottom of the bedplate and is drained to one end of the engine. The lower half of the bearing shell, seated in a machined housing on the bedplate, is half-round and can be removed by lifting the shaft slightly and then rotating the shell. The upper half is babbitted at the ends only, as the end surfaces are amply strong to withstand the lifting action of the shaft due to the acceleration of the rods and pistons. The shells are provided with oil grooves and are beveled at the side partings.

Both ends of the connecting-rods are of the marine type and both the bearings or pin boxes are of cast steel, tinned and babbitted. The fact that this is possible on the gudgeon-pin box is probably due to the location of the pin at some distance from the piston head. All McIntosh & Seymour engines have this feature, and no piston-pin trouble has been attributed to it.

The wristpin is ground on the pin bearing surface and has both ends resting in straight bosses, being held by setscrews. The pin is lubricated by means of a V-groove on the surface of the piston. An oil line leads from the oil pump through the cylinder wall, and the pump is timed with the engine piston so that at each piston stroke a jet of oil is deposited in the V-groove on the piston. From the groove a channel leads through the pin boss and the pin, allowing the oil to reach the bearing. This has proved satisfactory with the stationary Diesel and insures positive oiling of the pin.

The piston is of one-piece construction and is fitted with eight rings, all of which are located around the upper end. The head is reinforced by six radial ribs, and the barrel is strengthened with four girth ribs. No cooling of the piston is contemplated other than

natural air circulation. Experience seems to prove that cooling is unnecessary with pistons under 20 in. in diameter. The top of the piston is concave, which feature is claimed to assist in mixing the oil and air charge and to improve combustion.

The cylinder is of cast iron with a bolting-down flange at the base. Into it is pressed a liner that is machined all over, as required by the Marine Underwriters. The cooling water enters the jacket at the bottom, leaves through passages in the top flange and then flows through the cylinder head. The joint between head and cylinder is of the usual male-and-female type. As a further aid in keeping the joint water-tight, rubber tubing is used to form gaskets around each of the water passages as well as around the cylinder bore. With this arrangement any leaking water betrays itself by flowing out of the joint rather than into the cylinder bore.

The cylinder head is a round casting provided with openings on the top for the admission, exhaust, fuel and air-starting valves. The fuel-valve cage is seated in a bushing pressed into the head, this design insuring better cooling of the valve cage and providing a better cooling space in the head. Both the admission and the exhaust passages are on the same side of the engine. The exhaust header is of cast iron and is in six water-cooled sections. The air header consists of a flanged elbow to which is connected a short section of pipe slotted on the sides and closed at the bottom.

The admission and exhaust valves, which are of the same dimensions and are interchangeable, are mounted in cages, as shown in the sectional views of the engine cylinder in Fig. 2. The cages are of cast iron and have no water-cooling cavities or removable valve seats. The valves rest in long sleeves, the valve springs being placed between the sleeves and the outer or free ends of the valves. No dashpot or spring cap, as it is at times called, is used. The valves have steel stems on which the cast-iron heads are cast. The fuel valve is of the familiar Hesselmann design. Its valve cage is in two parts. The upper, containing the valve spring and dashpot, can be removed without disturbing the lower half. The valve is actuated by a rocker *A*, Fig. 2, that drives a short rocker or dog *B*, one end of which bears on the valve-stem nut *C*. The rocker *A* has hardened steel pins on the ends which can be adjusted to give the required roller clearance, and is driven from camshaft *D* through the reach rod *E*.

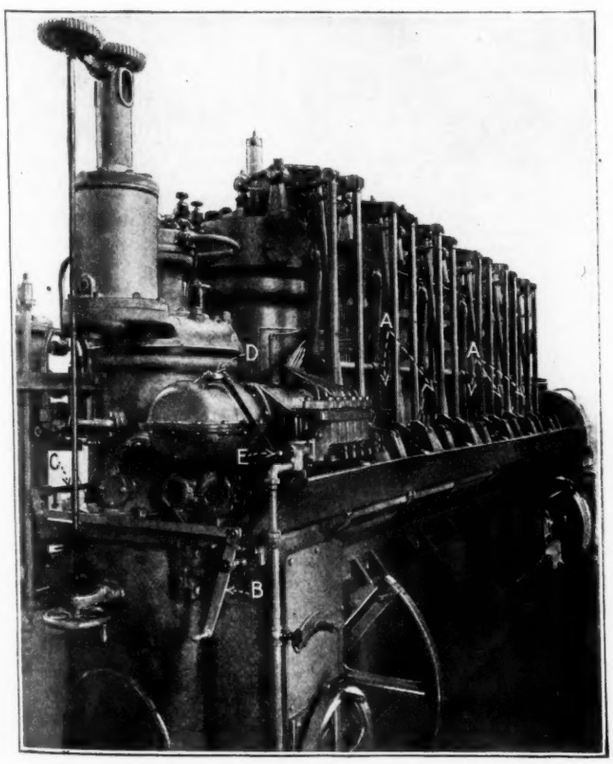


FIG. 1. SHOWING THE CAMSHAFT SIDE OF ENGINE

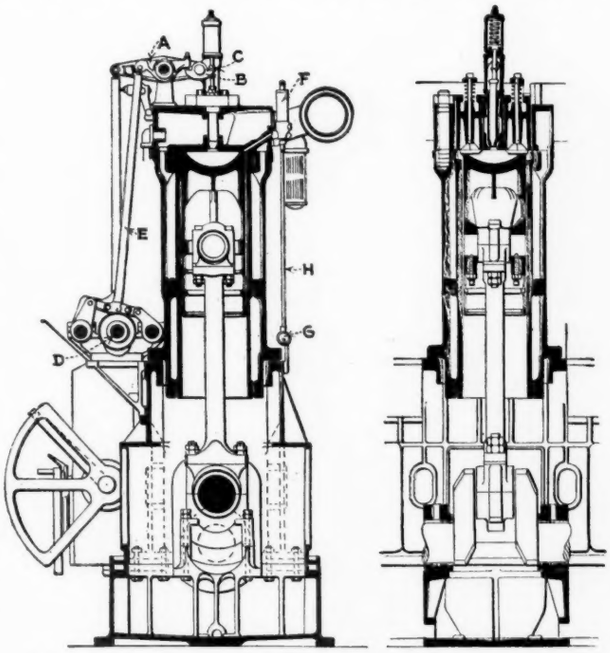


FIG. 2. TRANSVERSE AND LONGITUDINAL SECTIONS THROUGH CYLINDER

Compressed air, stored in a steel tank at a pressure of some 1000 lb. per sq.in., is used in starting the engine. The starting valve is controlled by a push-rod from the camshaft and is provided with an arrangement whereby it will not open in starting if the cylinder contains a charge of air or combustibles higher in pressure than the air in the starting tank. The push-rod has a spring-loaded cylinder *A*, Fig. 1, near its lower end. If the pressure in the engine cylinder is too high, the upward travel of the lower end of the rod will merely compress the spring inside the cylinder, without moving the upper end of the rod and the valve will not open; but as soon as the engine-cylinder pressure drops, the upper end of the rod begins to function. This is of special value when the boat is maneuvering, as frequently the air starter is thrown in before all the cylinders have been cleared. The air from the bottles is throttled to 150 lb. per sq.in. before entering the starting valve.

A relief valve *F*, Fig. 2, is placed on each cylinder and acts automatically. It is also used as a compression relief at starting. The lever *B*, Fig. 1, is pulled over, thus turning the shaft *C*, which extends the full length of the engine. This shaft, as shown in Fig. 2, carries an eccentric *G* from which a rod *H* leads to the relief valve on each cylinder. Thus, turning the shaft *C*, Fig. 1, opens the relief valves and decreases the resistance and so facilitates starting.

The valve rockers for the various valves on each

cylinder fulcrum on a rocker-shaft supported by two pedestals on the cylinder head, as may be seen in Fig. 1. In removing a valve cage, the entire rocker assembly is unshipped. Since the engine is reversed by lifting the push-rods off the cams, moving the camshaft endwise to bring a second set of cams into position and then lowering the push-rods, there is a period during the shifting when the valve-rocker push-rods are no longer in contact with the cams. It becomes necessary to support the rods during this interval, and that is accomplished by the arrangement in Fig. 3, which shows details of the valve rockers, push-rods and cams. A lever *A* is pivoted at the edge of the cylinder head and its upper end engages a roller *B* on the rocker-arm. A spring-loaded link *C* connects the lever *A* to the valve push-rod *D*. While the engine is running, the lever *A* is not in contact with the roller *B*, being held in position by the link *C*, which causes the lever to rock slightly as the rod *D* rises and falls. When the cams are to be shifted and the push-rods are raised clear of the cams by the movement of the reversing gear, this lever *A* is pulled into contact with the roller *B* by the action of the push-rod *D*, the lower end of which is swung to the right by the turning of the shaft *E* carrying the arm *F*. In reversing, the admission, fuel and exhaust push-rods are all moved to the right, while the starting-valve push-rod *G* is moved to the left by the swinging of the arm *H* on the shaft *I*. This is done in order to clear the cams as the latter are shifted along with the camshaft *J*. As soon as the cams are in the new position, the push-rods are dropped onto the cams that are then under their respective rollers. The camshaft is driven from the engine crankshaft by a set of two-to-one spur gears.

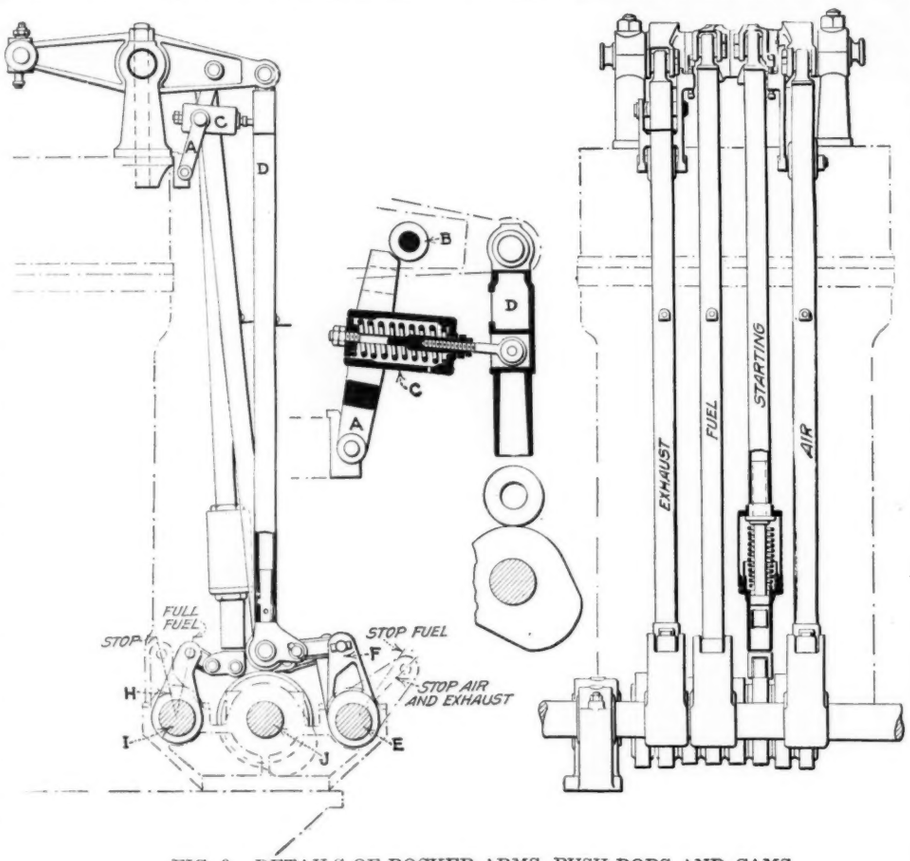


FIG. 3. DETAILS OF ROCKER-ARMS, PUSH-RODS AND CAMS

Two sets of cams are provided for each cylinder and are arranged in the following order on the camshaft—exhaust, fuel, air-starting and admission. They are made of cast iron chilled on the contact surfaces. The noses, or high points, of the admission and exhaust cams are finished to accurate measurements, while the fuel cam has an adjustable steel nose by which the fuel-valve timing can be altered.

The reversing and control gears are placed at the forward end of the engine, as may be seen in the foreground in Fig. 1. When the reversing wheel is in neutral position, the engine is set for running ahead or astern by rotating the wheel twice. This movement shifts the valve push-rods from contact with their cams and slides the camshaft horizontally, bringing the proper cams under the push-rod rollers. The mechanism whereby this is accomplished is outlined in Fig. 4. The handwheel *A* is keyed to a short shaft *B* that carries a bevel pinion *C* meshing with a bevel gear *D*. The bevel gear is keyed to a shaft *E* that carries a spur pinion *F* which meshes with a rack *G*. The shaft *E* also carries at one end a crank *H* connected by a rod *I* to an arm *J* keyed to the reversing shaft *K*. Turning the wheel *A* therefore swings the arm *J* upward to the left and so rotates the reversing shaft *K*, which is the shaft marked *E* in Fig. 3. This action lifts the valve push-rods out of contact with their cams. The same movement of the wheel *A* that lifts the push-rods forces the rack *G* downward by rotating the pinion *F*. The upper end of the rack slides in guides and is formed with a slot *L* in which moves a roller fastened to the lower end of the lever *M*. The upper end of the lever, which is pivoted near the middle engages a collar fastened to the camshaft *N*. As the rack is lowered, the roller slides in the vertical part of the rack slot without any transverse motion; but as soon as it strikes the inclined part of the slot it is moved to the right, throwing the upper end of the lever *M* to the left. This movement slides the camshaft endwise to the left, thus bringing the second set of cams under the valve push-rods for going ahead. This shifting occurs when the wheel *A* has made one revolution. A second turn of the wheel swings the crank *H* through the second part of its rotation, thus bringing it and the reversing shaft *K* back to their original positions, with the push-rod rollers resting on the go-ahead cams.

With the go-ahead cams in position to act on the push-rods, starting is accomplished by pulling down the control lever *O*, which is keyed to the shaft *P* and has a pointer that moves over the face of the graduated quadrant *Q*. At the inner end of the shaft *P* is a short

crank connected to the lower end of the rod *R*, the upper end of which is connected to a crank on the shaft *S*. This is the same shaft as is designated by *I* in Fig. 3. When the lever *O*, Fig. 4, is pulled down to the bottom of the quadrant, or to the point marked *start*, the shaft *I*, Fig. 3, is rotated and the lower end of the push-rod leading to the air-starting valve is thrown into engagement with the starting cam on the camshaft, with the result that air is admitted to the cylinders of the engine, causing it to start.

There is a connection between the shaft *I*, Fig. 3, and the shaft that drives the fuel pumps, so that when the air-starting cams are thrown into action the stroke of the fuel pumps is reduced to zero and no fuel can enter the cylinders. As soon as the engine has turned over a few times with the air, the control lever *O*, Fig. 4, is raised to the middle of the quadrant or the full-load point. This movement throws the starting-valve push-rod out of contact with its cam and at the same time shifts the fuel-pump shaft so that the pump delivers a full-load oil charge to the cylinders. The control lever is then slowly raised to the proper running position for the load carried, this movement producing a corresponding decrease in the fuel charges. When the control lever is moved to the stopping position, or the top of the quadrant, the fuel delivered by the pump becomes zero. The reversing wheel and the control lever are interlocked so that the reversing wheel cannot be shifted until the control lever is raised to the stopping position; furthermore, the control lever cannot be shifted to the starting or running position until the reversing action is complete.

The stroke of the fuel pump is varied to regulate the amount of fuel entering the engine cylinders. The pump has six plungers, one for each cylinder, mounted in a cast-iron block that also contains the discharge and suction valves. The plungers are driven by six eccentrics mounted on a short shaft geared to the engine camshaft through a clutch. The eccentrics are set on their shaft at an angle with the shaft axis, so as to allow the eccentrics to be moved to a position that gives zero throw to the plungers. The pump is equipped with an overspeed governor of the ordinary type mounted on an extension of the pump shaft. This governor, acting through the bell crank *D*, Fig. 1, moves the shaft *E* through a slight angle. The shaft *E* extends into the pump casing below the suction valves, and its angular movement raises the suction-valve stems and thereby opens the suction valves during the complete pump cycle. This governor acts only in case of overspeed.

The air compressor is placed at the front end of the engine and is driven by an overhung crank on the engine shaft. It is supplied with a pressure and volume regulator, shown in the upper foreground in Fig. 1. The regulator is a cylinder connected to the low-pressure air cylinder and contains a piston that is raised and lowered by turning a handwheel. The movement of the handwheel is transmitted to the piston by the vertical rod and the gears at the top of the regulator. By the proper displacement of this piston the low-pressure cylinder volume is altered to give any desired high-pressure discharge pressure. Some such an arrangement is highly desirable on all Diesels, since the injection air pressure should bear a constant ratio to the fuel charge deposited in the fuel valve.

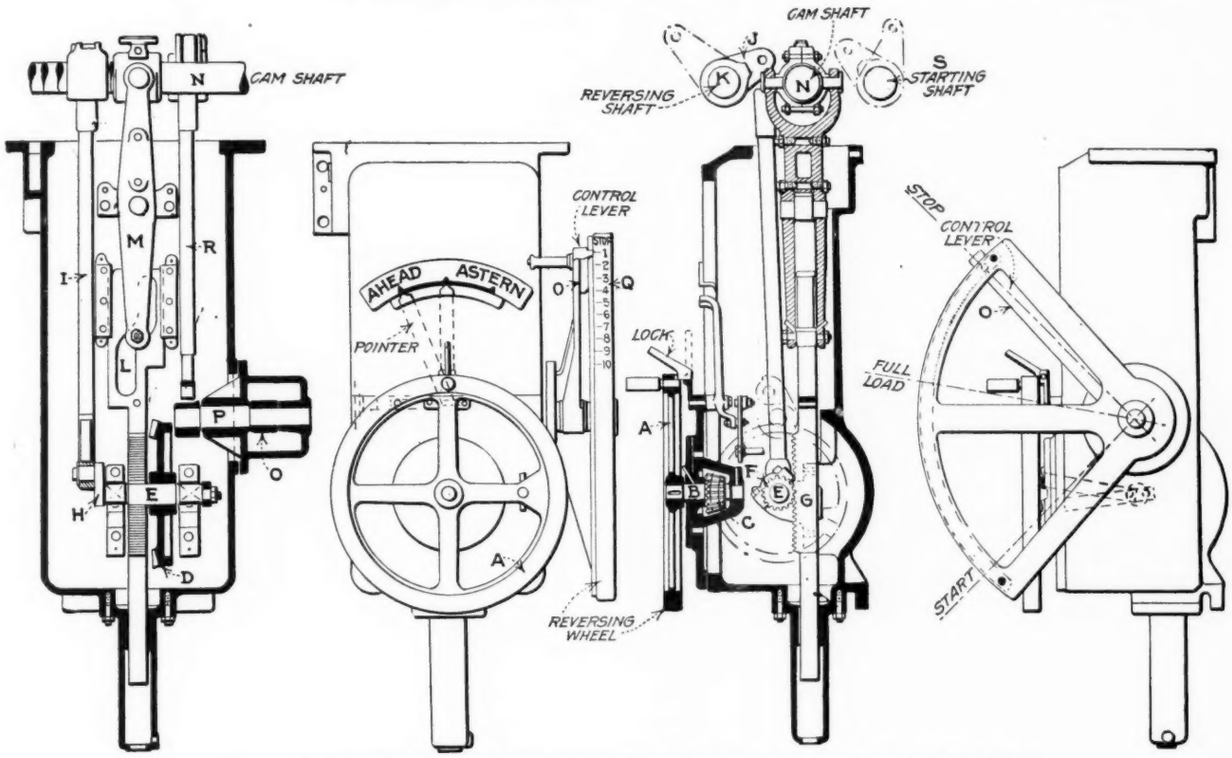


FIG. 4. ARRANGEMENT OF THE REVERSING GEAR AND CONTROL MECHANISM

The cooling of condensing water in a pond, a spray cooler or through a cooling tower, is obtained in three ways: First, by radiation, which is practically negligible; second, by conduction of absorption of heat by the air, which may vary from one-fifth to one-third of the entire effect, and third, by evaporation, which is the chief factor.

The Electrical Study Course—Inductances Used on a Three-Wire Generator

Shows how inductances used in connection with alternating current change the conditions that would exist if resistances were used for balancing. Briefly reviews the properties of inductances and introduces the fact that direct and alternating currents can be transmitted over the same conductors at the same time.

IN THE preceding lesson it was shown that, theoretically, a three-wire system could be operated by replacing the machines of a balancer set with two equal resistances whose value was very low as compared with the resistance of the load, but that such a method was impracticable on account of the large loss in the resistances. It was stated that the use of inductances in place of resistances, and their connection to the slip rings of a three-wire generator instead of to its direct-current brushes, would cut down the large waste found to exist in the case of the resistances and yet allow the unbalanced current to flow freely from the neutral to either outside wire.

To understand the principle upon which the apparatus operates, refer to Fig. 1, in which *A* represents the armature of a generator, *C* its commutator, and R_1 and R_2 two equal resistances connected to the armature winding at *c* and *d*. For the time being assume that these resistances revolve with the armature. In the position shown there will be a voltage of 220 volts across *cd* and current will flow through R_1 and R_2 from *c* to *d*. However, when the armature has turned through one-quarter of a revolution R_1 and R_2 will have assumed the position shown in Fig. 2. As explained at the time that the principle of operation of generators was under discussion, there will be no voltage across *cd* when they are in the position shown, and consequently no current will flow through R_1 and R_2. When the armature has turned through another quarter revolution, the conditions will be those of Fig. 3. It will be seen that 220 volts again exists between *c* and *d*, but that *c* is now negative and *d* positive, and that the current through R_1 and R_2 will therefore be from *d* to *c* instead of from *c* to *d*, as was the case in Fig. 1. When the armature has passed through another quarter turn the resistances will have reached the position shown in Fig. 4, which is similar to Fig. 2, and under the conditions of which no current flows through R_1 and R_2. When a complete revolution has been made, we again have the conditions of Fig. 1.

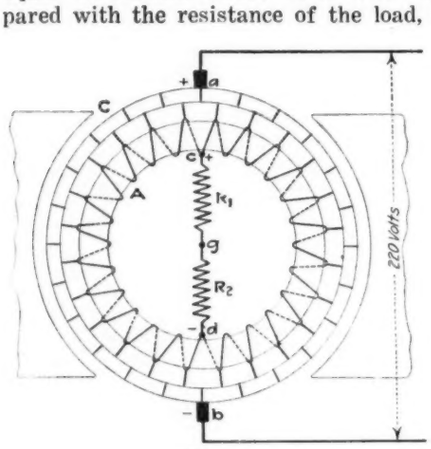


FIG. 1

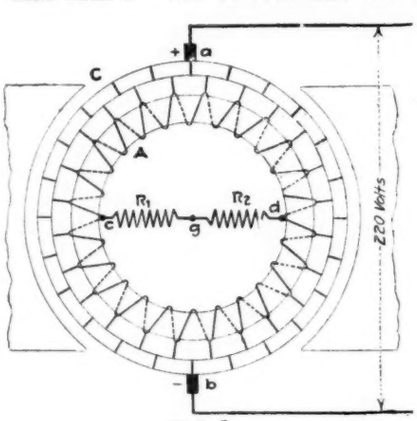


FIG. 2

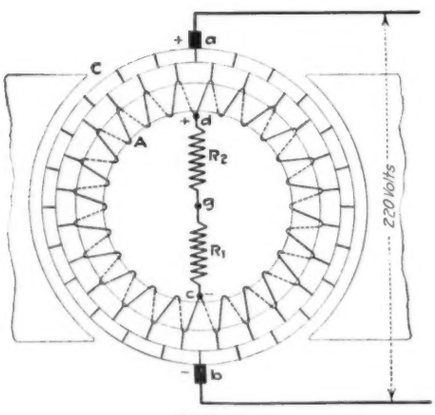


FIG. 3

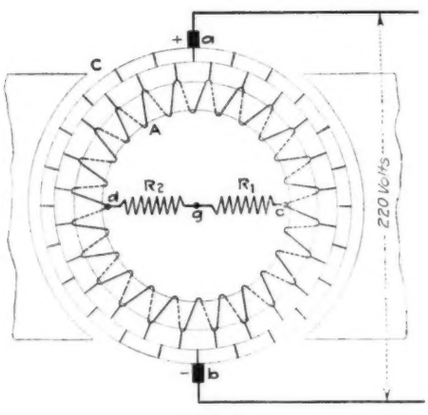


FIG. 4

FIGS. 1 TO 4. SCHEMATIC DIAGRAMS OF A RING ARMATURE WITH A RESISTANCE CONNECTED TO OPPOSITE POINTS OF THE WINDING

From the foregoing it is evident that the direction of the current through R_1 and R_2 is constantly reversing and the voltage across *cd* continually varying from 220 to zero and back to 220 in the opposite direction. That is, an alternating current flows through R_1 and R_2. If the resistances of R_1 and R_2 are small, the current through them will be great, just as in the case of direct current; but if in place of resistances we use inductances, the current may be made very small. This leads to a consideration of what an inductance is. As a matter of fact the discussion comes within the province of the subject of alternating currents, and the fundamental theory will therefore not be gone into at this time, the discussion being limited merely to the manifestions observed without giving the reasons therefor.

Suppose that we have a piece of copper wire whose length is 100 ft. and whose resistance is 0.1 ohm, and that it is stretched out straight. If 220 volts direct current were applied to its terminals, the current that would flow would be $\frac{220}{0.1} = 2200$ amperes. If 220 volts alternating current were applied, we would have prac-

tically the same result; that is, it would be immaterial whether direct or alternating current were used. Suppose now, however, that the same piece of wire is wound into a spiral, such as that shown in Fig. 5. Its resistance will remain the same and if connected to 220 volts direct current it will take 2200 amperes, as before, but if connected to 220 volts alternating current it will be found to take a much smaller current. Just how much smaller depends on the number of turns, their diameter and the size of the wire. If the wire be wound on an iron core as in Fig. 6, the effect will be greatly augmented, resulting in a much diminished value of current. Thus a coil of wire that would take 1000 amperes direct current might take only 5 amperes when connected to an alternating-current source of the same voltage. We cannot stop to investigate the reasons for this behavior, but will have to accept it as being a fact. Any coil of wire such as that described, is known in alternating-current practice as an inductance and is said to have a certain number of henries of inductance, in the same way that a resistance is said to have a certain number of ohms of resistance.

Suppose now that we replace the resistances R_1 and R_2 of Figs. 1 to 4 by inductances L_1 and L_2, as shown in Fig. 7. These inductances may have the same re-

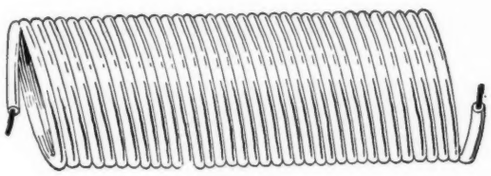


FIG. 5

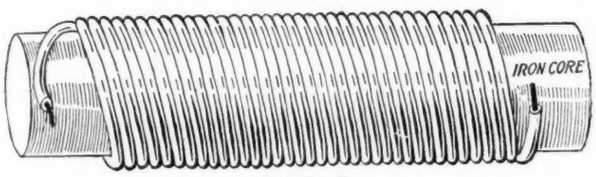


FIG. 6

FIGS. 5 AND 6. TWO TYPES OF INDUCTANCE

sistance as R_1 and R_2 had, and yet will take only a very small fraction of the current taken by them. Should any source of direct current, however, be connected across L_1 or L_2, a large current could be made to flow even by a small voltage.

We now come to a second unfamiliar proposition; namely, that an alternating current and a direct current can flow through the same conductor at the same time. This statement also will have to be taken on faith for the present as being so without any explanation of it. The fact is that if we were to impress an alternating-current and a direct-current source upon an inductance simultaneously, the former would be limited by the inductance, but the latter would be limited by nothing except the resistance of the inductance. As a matter of fact, this is the condition that exists in the inductances L_1 and L_2 when they are made use of in connection with a three-wire system.

To make this clear suppose the direct-current brushes a and b of the generator in Fig. 7 to be connected to the outside wires M_1M_2 of a three-wire system that has the same load on both sides, so that the resistance from M_1 to N is the same as that from N to M_2. It is evident that under these conditions the voltages E_1 and E_2 will be the same, each being 110 volts. Since the inductances L_1 and L_2, Fig. 7, are equal, the voltage from d to g equals that from g to c. When the armature is in the position in the figure the voltage from d to g or g to c is one-half of 220 volts, or 110. If the coils were in the position of the resistances in

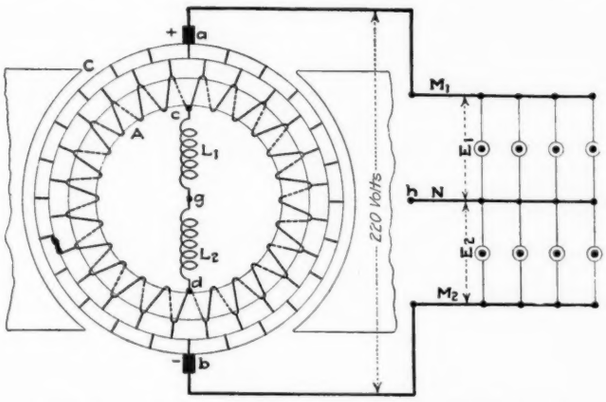


FIG. 7. SCHEMATIC DIAGRAM OF A THREE-WIRE GENERATOR

Fig. 2, there would be no voltage cross cd, but there would be one of 110 volts from a to d, d to b, b to c and a to c; consequently the voltage from a to g or b to g is again 110 volts. It is a fact that the voltage from a to g or from b to g is always one-half that from a to b irrespective of the instantaneous position of L_1 and L_2.

How this fact is made use of to create a three-wire system and how its functioning depends upon simultaneously transmitting both direct and alternating currents through L_1 and L_2 will be taken up in the following lessons.

In the preceding lesson the problem given consisted in finding the value of the voltages E_1 and E_2 in a system such as that illustrated in Fig. 8, if the load at X consists of 50 lamps of 150 ohms each and that at Y of 30 such lamps, if R_1 and R_2 each have a resistance of 0.5 ohm. The resistance of the lamps in multiple in load X will be the resistance of the individual lamps divided by the number in parallel; if R_x represents this resistance, we have $R_x = \frac{150}{50} = 3$

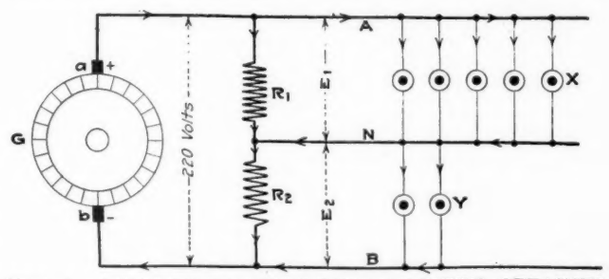


FIG. 8. DIAGRAM OF THREE-WIRE SYSTEM OBTAINED FROM TWO RESISTANCES

ohms. In like manner if the resistance of the lamps in parallel in load Y be R_y we have $R_y = \frac{150}{30} = 5$ ohms. The total resistance across AN is the multiple resistance of X and R_y, and if R_a be made to represent it, we have $R_a = \frac{1}{\frac{1}{R_x} + \frac{1}{R_y}} = \frac{1}{\frac{1}{3} + \frac{1}{0.5}} = 0.4286$ ohm.

Similarly, if the resistance across NB is R_b we have $R_b = \frac{1}{\frac{1}{R_y} + \frac{1}{R_2}} = \frac{1}{\frac{1}{5} + \frac{1}{0.5}} = 0.4545$ ohm. Then the total resistance of the circuit is $R = R_a + R_b = 0.4286 + 0.4545 = 0.8831$ ohm, and the total current will be $I = \frac{E}{R} = \frac{220}{0.8831} = 249$ amperes. The volts drop across any circuit is equal to the resistance of the circuit times the current in the resistance; this gives $E_1 = R_a I = 0.4286 \times 249 = 106.8$ volts and $E_2 = R_b I = 0.4545 \times 249 = 113.2$ volts.

It was further required in the problem to determine the capacity of the generator G required to supply the power to the system. The power output of the generator would be the current supplied by it times the volts at its terminals; that is, the watts $W = EI = 220 \times 249 = 54780$, or $\frac{54780}{1000} = 54.78$ kw. The generator would therefore have to be of a capacity as near this valve as could be secured, probably 60 kilowatts.

A generator is to supply a plain two-wire system with power. The load consists of 500 fifty-watt 110-volt lamps, and is situated 200 ft. from the generator. What would have to be the capacity of the generator? What size rubber-covered wire would be required for the mains? How much would the generator have to be overcompounded at full load to maintain constant voltage at the lamps?

Geared Turbines for Marine Propulsion

By LIEUT. CHARLES H. CAMP, U. S. N. R. F.

WHEN the great demand came for ships to meet the war emergency, one of the important problems presented was the prompt securing of propulsion machinery. To obtain an adequate number of reciprocating engines in any reasonable time was impossible. In spite of the fact that none of the companies manufacturing turbines for ship propulsion had adequate special departments (two of them had no such departments at all) for large production, or a sufficient number of men with the necessary specialized experience to handle such production, the geared turbine offered the only solution to the problem.

Anyone with experience in any line of production understands the multitude of problems presented by the manufacture of any new article or comparatively new article, no matter how simple that article may be or how adequate the force of men, specially trained in that line, who are handling it.

What, then, can be said of such an intricate problem as the immediate production on a large scale of marine geared turbines, when there were so few men who had any experience to speak of in either the design, manufacture, installation or operation of them? Each one of these elements is vital to the success of the machine. In the beginning none of them were present completely, and individually only in isolated cases, if at all. If any person wishes to dispute this statement, let him ask himself how much he has learned the past year and how much he is still learning, or, if he thinks himself proficient in his particular part, if he had the coördination of the other elements.

The truth is that when the demand came none of the companies had enough ships equipped or for a long enough time to have formed any definite opinion regarding what problems had to be met or how successfully those known were being met. Doubtless none of the companies relished the idea of launching out on a sea for which it had so few charts and such an inadequate force of officers and crew.

Naturally, many mistakes were made and a great amount of prejudice has been created against the marine turbine. Also, there is a reactionary element among marine engineers, as in all other walks of life, and this element seizes avidly on every occasion that offers half a chance to criticize the turbine. Many of them, without ever having operated a turbine set, express the opinion, "Give me the old reciprocating engine; none of your windmills for mine."

Most of the criticism of the marine-turbine unit is undeserved. The engineer who has the foregoing opinion will soon suffer the fate that any nonprogressive must meet. Fortunately, the marine engineers are a highly intelligent and progressive class of men. For the marine turbine has come to stay. In space occupied, weight per horsepower, economy of fuel consumption, upkeep, simplicity and flexibility, the marine geared turbine is now far superior to a reciprocating-engine installation.

With the problems that are to be met and the methods of meeting them pretty well understood and becoming better understood every day, there will soon be the same marked superiority of a marine turbine set over a marine reciprocating unit as now exists in a turbine over a reciprocating engine in central stations on land. Indeed, considering the factors enumerated, an official of one of the large steamship companies, nearly all of whose ships are turbine equipped, makes the assertion that even if they had to scrap the entire turbine set once a year, it would pay to use them in place of reciprocating units.

There is little to be said when the numerous variations of turbines aboard ship are considered, such as compounding, either by one high- and one low-pressure turbine, or two high- and one low-pressure or a multiplication of these combinations on one, two or three propellers, or divided slow turbines, or electric drive with current supplied by turbo-generators in an infinite variety of ways and all with a flexibility of control and manipulation impossible with any other present type of unit. In these matters the turbine has no rivals. In economy the Diesel engine is the only unit offering competition. But the superiority of the Diesel engine in this respect is overcome by the many difficulties besetting its operation and upkeep in its present state of development.

A good many of the problems in marine geared turbine sets have arisen from a perhaps unconscious desire on the part of the builders to emphasize the preeminent advantages of their unit—small weight and space occupied per horsepower. In any event it is a

fact that foundations, turbines and gears have been built too light and too compact for proper and necessary periodic inspection. They can be built of ample strength and size and of a design to permit inspection of all parts, the obtaining of bearing clearances, etc., and still retain their advantages to a marked degree.

Foundations of insufficient strength under turbines, gears and main thrust bearings have led to an endless amount of trouble due to the ship's "weaving," causing independent movements of the different elements, the gears taking a movement independent or in excess of the turbine, or, where an independent main thrust is used, a change in relative positions with that element. These movements result in misalignment, of course, and not only are excessive stresses set up in all parts, but the perfect meshing of the gear teeth is disturbed, decreasing the area of tooth contact (already too small) and resulting in extreme tooth pressure. Extreme tooth pressure, whether due to misalignment or original design, not only forces out the oil, thereby eliminating lubrication and causing excessive wear, but creates adhesion of the pinion and gear tooth surfaces in contact, and when separation of these surfaces occurs small particles of the metal are pulled loose. This last effect is the so-called "pitting." It is cumulative, as each particle pulled loose decreases the area of effective tooth contact.

Builders are now installing very heavy, well-braced foundations and adopting flexible construction to compensate for "weaving" and for the change in alignment that occurs when a ship is loaded or light.

Improvement in Methods of Lubrication

Methods of lubrication are being steadily improved. The old direct-pressure system was faulty, not only on account of the great rapidity, constant movement and number of times a given unit of oil was whipped around its circuit in a given time, but because periodic "dry spells," however brief, were constantly occurring over all parts of the system, due to air bubbles and the pulsations of the pump. Methods of application of the oil to different parts have received the attention their importance demands. Methods of settling, filtering and heat-treating of oil are also provided in modern installations. The manufacturers of lubricating oils have made exhaustive studies and tests on grades of oil best suited to the work.

An all-important factor in the success of any machinery is in its care and operation. At the beginning of the war a very limited number of marine engineers had any experience with turbines. A tremendous amount of credit must be given to these engineers, not only for their quick grasping of the turbine and for their adaptability, but for their great courage and patriotism in taking assignments on turbine-driven ships under all the circumstances—experimental stage of construction and installation, meager knowledge and at that time an almost total lack of instructive literature or even blueprints to show what made it tick—when it was a mighty dangerous proposition and one requiring high courage to sail the seas with most reliable, tried and true and familiar machinery.

The manufacturers must come to realize the necessity of more instructive literature. The United States Navy, which leads the world in its instructive courses and literature for its officers and men, has entered with its traditional spirit and efficiency into the undertaking of turning out more men and more competent men for operating turbine-driven ships. An exceptionally fine course is provided at the Carnegie Institute in Pittsburgh, combined with study at various turbine factories. The Shipping Board is also working along educational lines.

Accessibility for Inspection Is Vital

But the most efficient operator is going to be seriously handicapped and sudden serious breakdowns will continue to occur unless the manufacturers wake up to the fact that they must make their units more accessible for the inspection of parts and the taking of clearances. As it is, a turbine must be completely dismantled to inspect blading, diaphragms and other internal parts; the turbine bearing clearances and in most cases the turbine thrust clearances cannot be ascertained without a considerable job of dismantling; there are always six or eight bearings in the gear case that cannot be examined for clearances or condition without a prohibitive amount of dismantling; alignments also require a prohibitive amount of dismantling to check up, and in many types the same is true of flexible couplings, emergency governors, etc. A machine hard to inspect or test is seldom inspected or tested. In nothing more than in machinery is it truer that "a stitch in time saves nine." The way marine turbine sets are constructed at present, a complete failure of a part is usually the only indication that it is not in perfect condition. The engineer or inspector from the United States Navy, Shipping Board or turbine factory makes inspections every time a ship is in port, but on account of the present type of construction a great many important features that should be included in a thorough inspection have to be left to chance or insufficiently surmised from evidence shown by other parts.

Turbine manufacturers must consider gains in economy on marine sets the same as on land. There are even reciprocating-engine ships using a superheat of 200 deg. F. This should be used on all turbine ships. Pressures, vacuum apparatus (this has reached a high state of achievement), nozzle areas, stages, efficient steam separators, maintenance of high feed-water temperature, proper jacketing and prevention of the use of excessive steam for steam seals are all matters as easily taken care of aboard ship as on land and will gain the same marked superiority in economy.

Insuring Dependability and Economy

As a matter of safety two turbines cross-compound are safer than the single unit and make reaching a port under steam almost a certainty. With more substantially constructed foundations, gears and turbines, proper safety devices and better-trained operators the dependability of a marine turbine set is very good. With the elements affecting economy taken care of, their economy is unapproachable by any other steam unit. They are inherently the most flexible, and with an engineer who understands his turbine, the handling of the ship is every whit as good as, if not better than, with a reciprocating unit. With proper facilities provided for an easy, thorough inspection; with gears

built with teeth of proper pitch and angle, properly designed and correctly cut; with the tooth pressure kept in proper limits and with proper oil and methods of handling and applying it, the marine geared turbine set will show as marked a superiority over reciprocating units in upkeep and delays due to breakdowns as they do on land in both this feature and in economy. In space and weight per horsepower there is no comparison.

The turbine companies, whether through lack of coordination, ultra-conservatism or lack of courage of their convictions, are not going ahead as fast as they can on lessons they have already learned and problems they already know how to meet. Yet it is a fact that right now they know how and can build and will ultimately build a unit that will rank head and shoulders above any other type of marine steam unit, viewed from any angle, except in the multiple-maneuvering requirements of battleships, for which the electric drive with current from turbo-generators is best suited.

Care of Flue-Gas Treaters

By J. M. Wauchope*

The system of precipitation of solids from flue gases as developed by Dr. F. G. Cottrell has been described in various magazines, therefore this article will be devoted to the practical operation of such plants as viewed from the operator's standpoint.

As is well known, the principle of operation is the passing of the gases to be treated through a strong electrostatic field, the field being commonly produced by suspending wires in the center of vertical iron pipes through which the gases are passed. The wires are charged negatively and the pipes positively and grounded. The voltages in common use run from 20,000 to 50,000, very seldom higher, depending on the distance between the electrodes and the conditions of the gas.

The current to produce the field must be direct, as alternating causes the field to reverse, resulting in smaller catch. The high-tension direct current is obtained by rectifying alternating current of suitable voltage by means of a mechanical rectifier.

Of the two systems of electrical equipment in use, there is a divided opinion as to which is the better. The individual motor-generator set is used to a greater extent, but many plants are being installed using power direct from the power mains. The writer is at present operating plants using both systems, those using power direct from the mains giving far better satisfaction; in fact, some units of individual motor-generator sets were so unsatisfactory to operate that they were changed to the direct system.

With the motor-generator sets the snapping is much worse where the conditions in the treater are not good, as there seems to be a tendency to surge, which is largely absent in the direct system. In the direct system the power is taken from the mains through transformers, generally stepping down from 2200 to 220 or 440 volts. These transformers and the large system back of them seem to act as a cushion to smooth out the high-voltage surges caused by arcing or bad gas conditions in the treater. In cases where a very high resistance had to be used in the high-tension leads to the rectifier in order to operate with the motor-generator sets, by changing to the direct system this could be largely done away with and much better operation resulted. It is necessary in all cases, however, to have suitable choke coils in the alternating-current leads from the high-tension transformer for its protection.

It has been feared by some that in using the direct system there would be danger from high-voltage surges being reflected back to the power mains, but the writer is of the opinion that there is no basis for this, since the units operating this way have given absolutely no trouble and the operation is much better. The low-tension circuit between the two transformers is grounded through a resistance to drain off any static that might accumulate.

A suitable inductance in the direct-current circuit is a great aid to smooth operation in many cases where there is a tendency to snap, and especially with the motor-generator system. It has been contended by some that the inductance will lower the power factor, but the benefits are so large and the change in power factor so small that the former far outweigh the latter. The inductance is especially valuable in case of broken wires in the treater, or other severe arcing, as it smooths out the wave and protects the transformer from the surges. As the voltage in the treater should be carried as near the arcing point as possible, anything that aids in smoothing out the direct-current voltage wave is beneficial. Also, as large a percentage of the alternating-current wave as possible should be rectified. In the form of rectifier that has four arms in a set, there being two sets, the inductance allows these arms to be placed so that a larger portion of the wave can be rectified without snapping, which is conducive to more efficient operation.

A certain amount of resistance is necessary in the low-tension alternating-current circuit for ballast, in nearly all cases, as it tends to make smoother operation. The collecting brushes on the rectifier should be set as close to the revolving element as possible, so that power will not be wasted due to a large air gap. Operators should at all times see that the voltage is as high as possible for good operation, as it is liable to vary quickly with a change in gas conditions.

A gas that is too dense is not cleaned as well as one of the correct density. The pipes and wires should be cleared of all deposits before they become heavy enough to interfere with good operation. Air leaks into the treater should be watched for and the insulators inspected often. Of course if an insulator breaks down completely it is soon known. With some gases, if they become too dry, snapping will start, which can often be stopped by spraying water into the gases where they enter the treater, moisture being beneficial in some cases.

There is a tendency among some operators to take the milli-ampere charging current as an indication of the operation of the treater. However, this cannot be depended on, as the charging current will vary considerably, and yet the recoveries may be consistently good or just the opposite. The absence of a white snappy spark on the rectifier is an indication of good operation. The spark should be of a purple color and hiss rather than crackle.

Everything about the treater and station should be thoroughly grounded, as static charges have a way that is very surprising at times of collecting in places on ironwork. A heavy sheet-iron guard should be placed around the rectifiers, for they have been known to burst with startling results at times, and all the high-tension wiring should be inclosed by heavy grillwork.

*Chief electrician, International Smelting Co., Tooele, Utah.

EDITORIALS

Installation Cost Versus Maintenance Cost of Electric Equipment

IT IS not as generally recognized as it should be that the cost of carrying on a suitable preliminary engineering study prior to making an electrical installation, with the object of obtaining the electric equipment best suited to the work to be done, is a good investment. The perfunctory selection of control and motor equipment may lead to a very unsatisfactory installation with its attending high maintenance costs. It is not enough that a motor or controller be of excellent construction and workmanship—they must also be designed for the duty they are to perform. Not infrequently installations that have been made at great cost for high-grade equipment have been failures because of improper application of the equipment, when, if a proper study of conditions had been made, a less expensive equipment suited to the work to be performed would have given excellent results. Improper applications of electric drives have led to expensive replacements of motors and control equipment, with the attending increased cost of installation, radical rearrangement of drives, etc., not to mention the loss in production due to interruptions.

On the other hand, there is the cost of maintenance to be considered. The cost of installation is a factor that can be determined with a fair degree of accuracy, but maintenance expense is very difficult to determine, since not only must the expense of keeping the equipment in running condition be considered, but also the loss in production due to interruptions; and in some cases an inferior product may result. An improper application of an electric drive always leads to high maintenance charges. If the controller is too light for the service requirements, severe burning at the contacts and excessive heating of the resistance are the results, and if not properly designed for the duty to be performed, the motor cannot function properly even if suited to the work, and thus the cost of upkeep of the driving medium is increased. Overloaded motors give all kinds of trouble and underloaded motors are inefficient.

There are two methods of maintenance: First, the kind that makes repairs only when forced to do so by a shutdown, which to say the least is expensive and unsatisfactory; second, the kind that keeps the equipment in operation, that gives the machinery a little attention each day, and locates and remedies the defects before they have time to develop trouble. There are cases where the direct maintenance cost of the latter may be more expensive than the former, but when compared with the increase in production obtained by the latter method, there is no comparison between the two. The latter means a practically continuous operation of the equipment, where the former leads to all kinds of expensive interruptions and dissatisfaction.

The installation of motor and controller in inaccessible places where they cannot be taken care of, just to economize in a little floor space, is false economy. If the attendant is to be expected to take care of the equipment, it must be placed where it can be given attention without excessive effort. If this is not done, it is immaterial how conscientious a workman may be, he generally gets disgusted with having to keep up machinery where he has to subject himself to all kinds of inconveniences to do so, with the result that the equipment is neglected.

In this period of reconstruction, when manufacturers are looking for ways and means of reducing cost and increasing production, the electric drive should be given serious consideration. If it is not properly selected, installed and maintained, it may mean the difference between a high cost and a low cost of production.

The Underpinning of Faith

AMERICA had only begun to fight when the armistice was signed. No one realized this more than Fritz himself. His moral sense was a minus quantity and his understanding of psychology was ludicrously inaccurate, but he still retained enough sense to appreciate that he was a beaten man and that to prolong the conflict was but to convert defeat into disaster and transform reverses into a rout. So he sent out the white flag and the crash of cannon ceased.

By that strategy he saved his face, and he cheated the Allies of the chance of punishing him as he deserved, of dealing with him as ungently as he had dealt with Belgium and of sending back to him with compound interest the devastation and death he had loosed upon a peaceful earth. But the military Frankenstein he had created was about to turn and rend him.

For America had more than two millions of men in France and millions more in training; ships were building to transport them; munition factories were just beginning to hit their stride; chemical plants were producing poison gases of a deadliness and effectiveness such as the Hun never dreamed; great bombing planes were being assembled, in preparation for the days when destruction should descend like hail on the Fatherland and the horrors of warfare be brought home to the willing worshipers of a swashbuckling sham.

A mighty machine was in motion toward the Rhine. From the days of its first faint stirrings at Seicheprey it had gathered speed and momentum until no organized resistance could stand before it. That machine was conceived, built and motivated by faith—the faith of the American people in the justice of their cause, the ability of their leaders, the strength of their own arms and the inexhaustible resources of their homeland. It was that quenchless faith which proved the undoing of the Hun and paved the way for the imperial skedaddle to Amerongen.

Behind that faith, what?

The power of the almighty dollar—the selfsame dollar that Europe had professed to regard as the American's god, that she liked to ridicule and yet that she never declined to take from tourists possessing greater generosity than good judgment. That was the material foundation for America's effort.

All the vast wealth of the nation was pledged to the furtherance of our activities in the war. Fortunately, we needed to use only a small part of it. But the intent and the promise were there. We were as one in the determination to spend the last red cent, if need be, to wipe the red smear of Prussianism from the face of the world.

The task is not ended. We have only partly completed the job. We have removed the menace of German domination, but we have not discharged our fighting forces. There is yet a great army abroad to be fed, clothed and brought home. There are the disabled to be cared for and trained for gainful occupations. There are camps and hospitals to be maintained. There are enormous war debts to be paid.

These are the reasons for the Victory Liberty Loan so soon to be launched. Our war expenses have not ended with the ending of hostilities. It was utterly impossible to dismantle in a day the titanic war machine that we had built. Therefore our expenses must continue.

The fifth loan is to finish a work nobly begun and splendidly carried forward. It is to redeem the pledge of the nation to see the whole affair through to a successful ending.

The job will not be properly done until the Victory Loan is fully subscribed.

Developing the Water Power of Maine

WHAT a pity that Maine does not occupy the geographical position of Massachusetts or Connecticut! With her abundant resources in water power she would exert a most favorable influence upon the industries of New England. But, after all it is perhaps well that this most northerly state on the Atlantic, far removed from the coal fields, has so many large rivers on which many hydro-electric stations may be built. It greatly adds to the cost of steam power to the people of that state because the charge to take coal from Hampton Roads to her ports is high.

A special investigation of Maine's water-power possibilities shows that 700,000 horsepower is available. Half a million is available on the Kennebec, Androscoggin and Saco; only half of this is now developed. The Kennebec will yield about 230,000 horsepower, though only 40,000 or about one-sixth is at present developed. The Androscoggin ultimate practicable yield is 160,000 of which 120,000 is already developed. The Saco can produce 50,000, and two-thirds of this is now developed. On the six great rivers of Maine fifty-five per cent. of the available power is developed.

The Public Utilities Commission for that state believe that existing plants, aided by storage, can meet the demands for power for several years to come. This is likely true, as unusually great storage capacity is available at a remarkably low cost. But many of the public utilities now producing and selling power are hard pressed to meet peak demands. To increase the station capacities for each of these companies doubtless would mean expenditures far in excess of the amount required to build a station and utilize some of the undeveloped power, distributing it over trunk lines to all the companies which need it. The commission touches upon this problem. How such a plan will be financed is a matter for the state and business to handle. There are several ways of doing it. The Kennebec is the great source of power for future needs in Maine, and storage upon it is to be had at low cost. It is of interest to know that engineers estimate that the average cost of developing the practicable resources is about one hundred dollars per horsepower. On the six great rivers, the Kennebec, Androscoggin, Penobscot, Presumpscot, Union and Saco, 79,000 horsepower increase may be had by storage regulation at the low average cost of thirty-four dollars per horsepower. If all suggested storage developments were made, there would follow an increase in primary power of 168,000 horsepower at a total cost of sixteen dollars per horsepower.

With such water-power resources, all possible of development at comparatively low cost, one may judge of the competition that such developments might give to the steam stations at tidewater. With storage regulation power can be transmitted to tidewater at from four to nine mills (six mills an average) per kilowatt-hour of primary power at the substation of the transmission line as against one and one-quarter cents per kilowatt-hour at the switchboard of large steam stations now operating at tidewater.

Peculiarly, the laws of Maine prohibit the exportation out of the state of power generated within the state. Thus Maine cannot tie in with other New England water-power systems. The commission says that other than railroads the total power generated by steam in Maine is but 230,000 horsepower. And Maine has not demand for anywhere near her total water power available. This should not, however, hold back development of her resources in power. She should sell it, reserving the right to curtail supply to without her borders for needs within as the demand rises.

Some interesting data on construction and operating cost of water power, with particular reference to Maine, are given elsewhere in this issue.

According to a newspaper item and credited to the *Great Lakes Bulletin*, the firemen on board ships seem to have a "snap." One paragraph is as follows:

> The daily routine of a man on watch consists merely of seeing that the fires are purple and the steam at the proper height before he relieves his man. From then on until his watch expires he merely has to maintain the required amount of steam up and watch his fires.

Maintaining a purple fire may be a sinecure, but we were under the impression that by the time a marine fireman had stood his watch and kept the steam pressure at the proper point and his fires in proper shape, he had done what might be considered a day's work.

The recent Mobile boiler explosion again emphasizes the pent-up energy in high-pressure steam boilers. The two boilers that exploded were fifteen and twenty years old respectively, and although repairs may have been made on them, it would seem that after such a period of service it would be advisable to reduce the working pressure somewhat and at the same time exercise greater care in the matter of inspection.

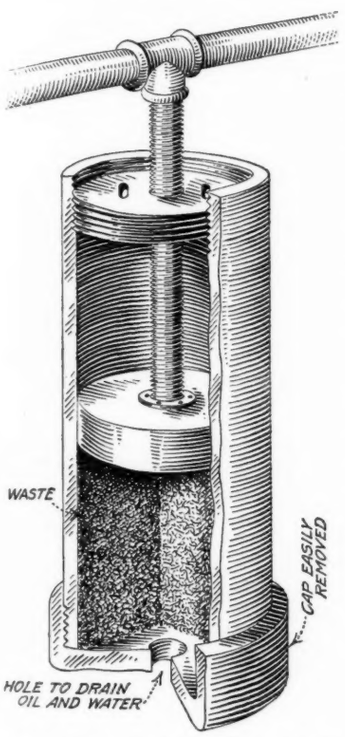
When we see some fellow take the floor every fifteen minutes at an engineers' meeting, we are reminded that a babbling stream has to spread itself considerably to make up for its lack of depth.

Most of us believe the thing that it is to our interest to believe. Witness the assertion of superior economy on the part of the central station as a power producer.

Correspondence

How Dirty Waste May Be Cleaned

Waste that is used for wiping machinery generally becomes extremely dirty with use and is then thrown on the coal piles. A better way would be to collect the waste in a suitable covered can and, when a sufficient quantity has accumulated, place it in a strong solution of common soda and boil it. A large proportion of the dirt and oil will be removed, and a proper rinsing will make the waste ready for use again. A press for squeezing out the moisture in the waste can be made, as illustrated, from a piece of 5-in. pipe. The pipe is fitted with a drilled cap on one end and a plug on the other, and the plug is tapped for a threaded ½-in. rod fitted with a piston on one end and a tee on the other. The piston can be made of wood. The waste is put in the press and the plug is then screwed into the end of the pipe, and by screwing in on the ½-in. pipe, excess moisture is pressed out. To remove the waste unscrew the cap and force it out by means of the piston.



PRESS FOR WASHED WASTE

JAMES M. PURCELL.

Richmond, Va.

Thermos-Bottle Principle Applied to Steam Cylinders

In the issue of Feb. 25, page 293, there was published a letter on "Thermos-Bottle Principle Applied to Steam Cylinders," in which the writer suggested that the jackets of cylinder-jacketed engines be connected to the condenser and radiation losses be thereby reduced. This idea was tested out very thoroughly in the laboratories of the University of Wisconsin some years ago. A compound condensing steam-jacketed engine was first carefully tested, both with and without steam jackets. Then the steam jackets were connected to the condenser and tests made at various vacua.

This vacuum apparently hadn't the slightest effect on the steam consumption. An extremely high vacuum pump was available and was connected to the jackets to produce high vacuum. Such vacuum had very slight effect on the steam consumption of the engine. It was therefore concluded that the use of the vacuum jacket had no effect whatever on the cylinder condensation, which is the serious loss in the engine, and further, that a perfect vacuum would be required to appreciably reduce radiation losses through the jacket space alone.

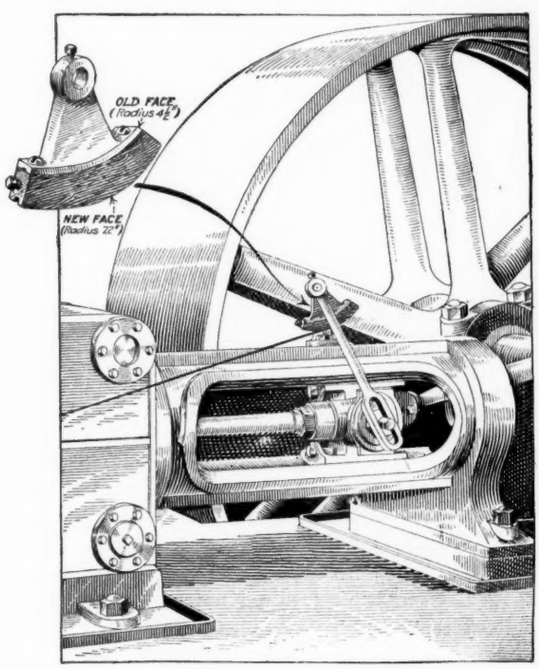
Such a vacuum cannot be obtained with an ordinary condenser. Furthermore, there would still be considerable radiation from conduction of heat through the metal cylinder heads, joints and ribs connecting the cylinder and jacket. These tests indicated clearly that nothing would be gained commercially by putting a vacuum on cylinder jackets.

A. G. CHRISTIE.

Baltimore, Md.

Altering a Reducing Motion

Some time ago I bought an indicator and reducing motion in order to secure diagrams from my engines, but when I used it I obtained a diagram only 2½ in. long, which was too short. Using the rule of proportion, I find it to be 2½ : 4½ :: 4 : 7.2 in. Thus the 2½-in. card



ALTERED REDUCING MOTION

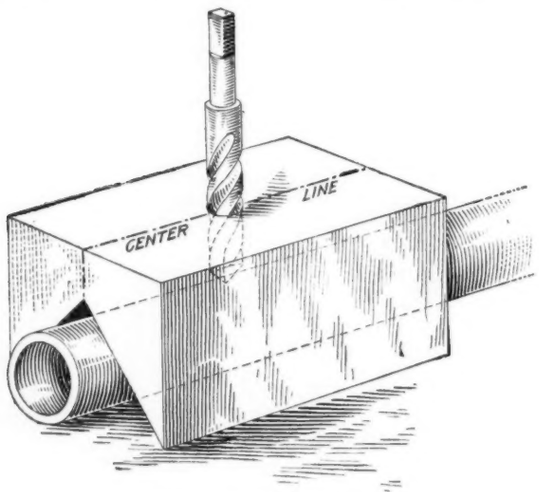
was made from a reducing motion, the face of which was 4½ in. from the center point.

A card 4 in. long would require a reducing motion having a distance of 7.2 in. from the center to the face. To obtain the proper travel of the indicator drums, I added a piece of wood, as shown in the illustration. This gave a card exactly four inches long.

St. Louis. Mo. M. J. MERRELL.

Preventing a Drill from Slipping

Having a number of holes to drill in a pipe, I at first experienced some difficulty, as the drill would tend to slip. I then took a block of wood, cut a true V-shaped notch and placed it over the pipe. A line was drawn through the center of the block corresponding to the



GUIDE FOR PIPE DRILL

bottom of the V and a hole drilled on this line. Putting the drill through this hole brought it on a center line of the pipe and at the same time furnished a support for the drill, thus preventing it from slipping. Pipe of different sizes can be drilled with this same block.

Richmond, Va. J. M. PURCELL.

Burning Fuel Oil in a Coal-Burning Furnace

Referring to page 411 of the Mar. 18, 1919, issue, and the short article relating to bagged boilers caused by burning fuel oil without change of furnaces, I would say that I have had two experiences of this kind, and from the many furnaces that have been changed to burn fuel oil in which the only alteration was to remove certain sections of the grates and place a baffle wall in the furnaces without any trouble whatever. I believe that the bagging in the instance mentioned was caused by the fact that at this particular point there was in this boiler a certain amount of scale or dirt that had collected directly over the bag.

In every case that has come to my notice, either with oil or coal fire, where a bag has developed, scale or dirt located at that point has been the direct cause, together with a too intense fire. A. E. WALDEN.

Baltimore, Md.

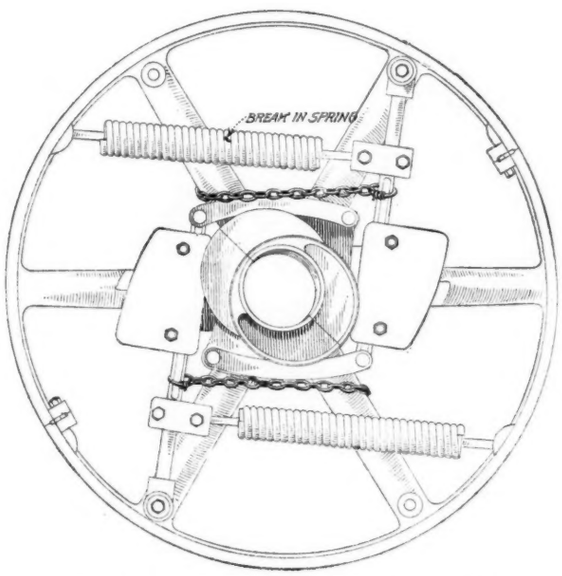
Engine Emergency Stunts

The editorial, "Helping the Other Fellow," in *Power*, Dec. 31, 1918, would no doubt result in benefit to progressive engineers if they would respond by telling about the stunts they have "pulled off" during their engineering careers. Many of them have good ideas which, if made public, would be of value to others and a source of gratification to the giver. As a starter I present the following:

The cutoff valve in the low-pressure cylinder of a tandem-compound engine broke in three pieces. As the accident occurred an hour before the peak load came on, something had to be done quickly because the other engines were too small to pull the commercial-lighting load. After giving up the situation as lost, the chief engineer disconnected the cutoff rod and used a chain to clamp the low-pressure valve firmly against the head end. This allowed steam to enter on the crank end. The engine was started in time for the show at the opera house at 8:15 p.m. and lasted just 20 minutes after the show was out. At midnight the valve chest was opened up and the broken cutoff valves removed together with the stretcher rods. Then the main valve was replaced and ran without the cutoff valves for 9 days, until the new ones arrived. The engine not only ran better without the cutoff valves in the low-pressure cylinder, but pulled 30 kw. more load, or 210 instead of 180.

In another instance the governor spring broke on a shaft governor just as the afternoon peak came on. As we had no spring in stock, we were up against it. So the chief pulled his hair and, after cursing a little, ordered the chain again. The weight levers were chained securely to their inner stops, about as shown in the illustration, thus giving the engine maximum valve opening. The engine was run throttled this way for over a week to help out on the peak head.

A new engine had been promised for the winter load, but at the last minute word came that the deal had fallen through. The chief talked plain English and told the powers that be what could be expected in the way of poor service. Finally, the manager borrowed an engine from another plant that had just discontinued the use of four 125-hp. tandem units. The borrowed engine



WEIGHT LEVERS CHAINED AGAINST INNER STOPS

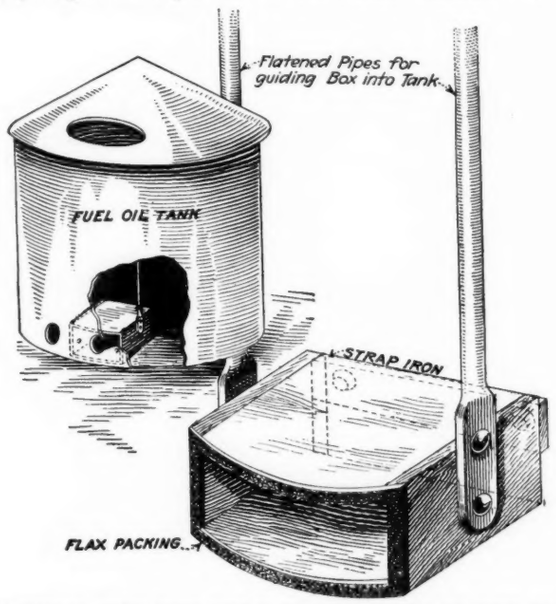
was connected up and running by the following Saturday night just in time to save the day.

In the meantime the engine that had been bought as junk was rebuilt and made a permanent part of the plant and was used to reduce the coal bill on Sundays, holidays and after midnight, when the load was less than 100 horsepower. So in the end the borrowed engine proved to be a good investment, as it saved over a ton of coal a day, or approximately 12 per cent. on the coal bill. WALDO WEAVER.

Franklin, Ohio.

Connecting an Oil Line to a Fuel-Oil Tank

A crude-oil tank, 20 ft. deep and 30 ft. in diameter had but one feed line going to the boiler oil burners, with the exception of a dangerous one that was connected to the water drain pipe of the tank. That, if used, might have put all of the boiler burners out of



SHOWING HOW THE HOLE WAS DRILLED IN THE TANK

commission or carried water to the burners, as it is connected in the bottom of the tank.

The need of another oil line was evident, and the problem was solved by putting a 4-in. connection in the side of the tank at the bottom. Not more than two or three buckets of oil was lost by the operation, as a pan was used to drain crude oil back to a small tank into which the oil is discharged from the cars.

A wooden box was made, 14 in. square by 8 in. deep, with the face made to fit the curvature of the tank. The edges of the box that came next to the tank were lined with flax packing and held in place with nails driven well in so as not to hold the packing away from the tank. A piece of strap iron was then screwed to the back of the box, and two $\frac{5}{8}$-in. holes were drilled and tapped through both. This plate was for the purpose of pulling the box up to the side of the tank by means of bolts extending from the outside.

Next, two lengths of pipe, each flattened at one end, in which two holes were drilled, were bolted one on each end of the box, so as to guide and let it down to the desired position in the tank. Corresponding holes were drilled in the tank to match the tapped holes in the box, so as to draw the box with flax packing tight against the tank. The holes in the tank were carefully drilled with an air drill running at slow speed so as not to cause heat or produce a spark, which would subject the oil tank to the danger of fire. As soon as each hole was drilled, a wooden plug was inserted.

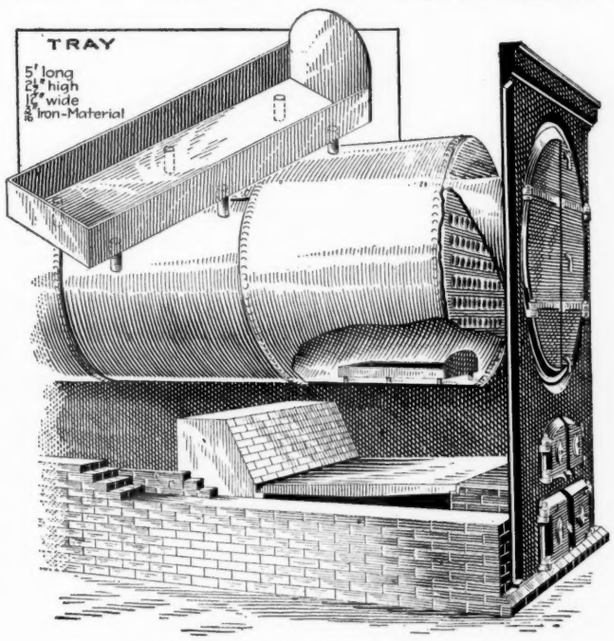
When all was ready, the box was lowered, through a manhole at the top of the tank, to its place corresponding to the holes drilled in the tank. The holes in the box were countersunk so as to be easily located when putting the bolts through after the box had been lowered to position, the bolts being inserted in the holes in the tank after the wooden plugs had been pulled out one by one.

The box was then drawn up to the tank securely, the plug in the center hole was pulled, and the oil in the box was drained out. A 4-in. flange was placed against the tank and central with the box. Then the bolt holes were scribed, also the bore of the flange opening. The center was drilled out with a small drill, and the bolt holes were drilled. The flange was then placed after putting an $\frac{1}{8}$-in. asbestos sheet gasket between the brass flange and the tank. The flange bolts were put in place from the inside of the tank by means of the flange opening in the tank and were drawn up tight. The flange was made of brass so as to obviate any chance of breaking when tightening. A nipple had been screwed tightly into the flange before bolting it to the tank, so as not to have any difficulty in screwing it in later, in case the flange should spring in bolting it to the tank. A valve was screwed to the nipple and then closed. The bolts were unscrewed from the box, leaving it free, and the bolt holes in the tank were tapped and plugged with patch bolts. The oil line was then put in service and has been in use ever since.

Sasco, Ariz. RALPH LEWIS.

Scale Deposited in Tray

One of several return-tubular boilers in a certain plant is fed through the blowoff line. The effect on the circulation of the water in the boiler was such that all loose scale was deposited on the front sheet over the furnace. This resulted in a badly bagged boiler on two occasions. A boiler inspector suggested



SCALE DEPOSITING TRAY IN BOILER

the introduction of a tray, as shown in the illustration. This is put in place through the front manhole. At times, especially when boiler compound is used, this tray is full of loose scale at the end of two weeks. No loose scale is found in any other part of the boiler. The use of this tray keeps the scale from piling up on the sheet and has done away with the old hazard of a bagged boiler.

J. L. BALL.

Amsterdam. Ohio.

Changes in Header Piping

Referring to the letter, "Changes in Header Piping," on page 327 of the Mar. 4 issue, I wish to state for the information of Mr. Wakeman that there is a large trap connected to the other end of the header by a 2-in. line. This was not shown in the previous article.

When sudden overloads come on, the unit that the 6-in. line supplies pulls over large slugs of water, and these are entirely too great in volume to be handled by a 1½-in. line, as suggested by Mr. Wakeman, to clear the 6-in. line as it should be done. What is to prevent the steam in the boiler from circulating up through the 1½-in. pipe to the header, in the arrangement described by Mr. Wakeman?

As for the excessive radiation surface, a good grade of covering has practically eliminated that loss.

Memphis, Tenn. J. A. LANDOLINA.

Mechanical Equipment of Industrial Buildings

In the article on "The Mechanical Equipment of Industrial Buildings," page 244 of the Feb. 18 issue, a calculation is made showing how the steam charged to the power account can be estimated where the exhaust from the engines is used to heat the building or for other purposes.

In this calculation an allowance of 20 per cent. is made for the loss in heat units by the steam in being passed through the engine due to condensation. Although this percentage is the one commonly used in making calculations of this nature, it would appear that it is too high in view of recent observations by operating engineers and others. A horizontal high-speed engine will not convert much more than 5 per cent. of the heat supplied to it into mechanical energy. To allow 15 per cent. for condensation seems excessive in view of the comparatively small area of the cylinder, steam chest, etc.

A 100-hp. high-speed engine with a water rate of 32 lb. would, under these conditions, condense about 500 lb. of steam per hour, and this condensation would take place in a cylinder the superficial area of which is about 15 sq.ft., or at a rate of 33 lb. per sq.ft. per hour. This rate is many times higher than that obtained from uncovered steam piping, and it would therefore appear that the assumption made as to the loss in the cylinder is somewhat liberal.

It is true that there is a considerable amount of initial condensation when steam is admitted to the cylinder at the beginning of the stroke, but this condensation is largely reëvaporated before exhaust takes place, so that it does not represent a direct loss in the heating value of the steam discharged by the engine into the heating system.

In addition to this, in exhaust steam there is undoubtedly some property which makes it more effective as a heating medium than live steam of the same pressure. Just what is the cause of this is hard to explain, but it is a well-known fact among operating engineers that a building can usually be heated more effectively and with a lower pressure on the system using exhaust steam than with live steam. Using a lower pressure in the system naturally reduces the steam consumption, and in many cases it would appear that, where all the exhaust can be utilized, no steam should be charged to the power account, as the coal consumption is the same whether the engines are running or not. Indeed, some engineers claim that they actually save coal by operating their engines and that on Sundays and holidays the steam consumption of the heating system is increased on account of the machines being shut down. D. F. GRAHAME.

Ottawa, Ont.

Calculating Heat Loss in Water

Replying to Mr. Molloy's query relating to "Calculating Heat Loss in Water," published on page 219 of the Feb. 11 issue of *Power*, I am of the opinion that he does not get anything like steam, or 212-deg. temperature, in his feed water.

It is a fact, acknowledged by authorities, that closed heaters are seldom provided with sufficient heating surface to raise the temperature to more than 200 deg. In order to raise the temperature of 1000 lb. of water from 60 to 212 deg., the heating surface would be almost 1 sq.ft. per hp., and it is not likely that Mr. Molloy's heater has any such proportions.

In regard to the heat lost to the sewer from the heater and the heating system, we may assume that it has a temperature of 212 deg. unless thermostatic traps are used and the temperature worked down to a lower point. In a plant with which I am acquainted about 27,000 lb. of water per hour is used. The raw water is at a temperature of 44 deg., and a closed heater raises it to 144 degrees.

The steam pressure carried is 100 lb. If the boiler plant has an efficiency of 50 per cent., the coal a calorific value of 14,000 B.t.u. and the loss of steam due to leakage, condensation and oil separators equals 20 per cent. of the balance being used for heating the building and the feed water and then going to the sewer at 212 deg., which I am satisfied that it does, the loss of coal to the sewer per hour would equal

$$\frac{27{,}000}{7000} \times \frac{80}{100} (212 - 44) = 518 \text{ pounds.}$$

As there is enough exhaust steam going to waste in the plant in question to heat the water to 212 deg. in an open heater, it looks to me as if Mr. Molloy's closed heater is an expensive proposition.

The heat units saved per hour by an open heater over that saved by the closed heater would equal $27{,}000(212 - 144) = 1{,}836{,}000$. On a basis of 50 per cent. efficiency this would equal $1{,}836{,}000 \div 7000 = 262$ lb. of coal per hour. There would also be a saving of water, the quantity being calculated about as follows: As the condensation in the heater is in contact with the water until it leaves the heater, its temperature must be 212 deg. The latent heat of the exhaust steam, 966 B.t.u. per lb., is the only heat used in heating the water.

The quantity of water heated by one pound of exhaust steam would therefore be $\frac{966}{144 - 44} = 9.66$ lb. And the quantity of condensation would equal $27{,}000 \div 9.66 = 2800$ lb. per hour, nearly. As Mr. Molloy gives no data in connection with his plant, no figures can be given for it, but I believe the foregoing calculations will enable him to solve his own problem.

Toronto, Ont., Canada. R. MCLAREN.

Inquiries of General Interest

Coefficient of Expansion of Mercury—What is the coefficient of expansion of mercury per degree Fahrenheit? J. V. H.

For practical purposes the cubical expansion of mercury may be taken as 0.0001 per degree Fahrenheit. The coefficient increases with the temperature. According to determinations made by Regnault, the mean coefficient between 32 deg. F. and 212 deg. F. is 0.00010086; between 212 and 392 deg. F. it is 0.00010338; and between 392 deg. F. and 572 deg. F. it is 0.00010646.

Magnet Coils Wound with Iron Wire—Has iron wire ever been used to any great extent for winding magnet coils, and what would be the objections to its use? A. S. M.

If iron wire has been used at all for winding magnet coils its use has been very limited. On direct current, the chief objections are the high resistance of the conductors, which results in a large and inefficient coil; the winding being made of magnetic material (iron) permits excessive flux leakage, which decreases the pull of the magnet. In alternating-current work there is the additional objection of the hysteresis and eddy-current losses in the winding, which also decrease the efficiency of the magnet.

Repeated Breakage of Gas-Engine Crankshaft—We are having considerable trouble from repeated breakage of the crankshaft of an 80-hp. producer-gas engine. May not the trouble come from improper adjustment or poor lubrication of the bearings and crank boxes? S. S.

Repeated breakages are more likely due to shocks from preignition and impacts to which internal-combustion engines are subjected. A crankshaft usually breaks after the material has become crystallized, and when a break has occurred, it may be taken for granted that more or less crystallization has taken place throughout the whole crankshaft material. The original structure can be nearly recovered by heat treatment, and the whole crankshaft should be so treated occasionally—at least whenever any part is repaired by rewelding.

Dull Black Finish for Brasswork—What treatment is given brasswork to impart a dull black finish? A. W. B.

Make a concentrated solution of copper in nitric acid and add an equal quantity of water. The surfaces to be blackened should be bright and washed clean of grease. If the article is large, swab the surfaces with the diluted copper solution; if small, immerse it in the solution. After draining or shaking off the solution, heat the article until the copper salt is converted to a black oxide. The heating may be done over a clean coal fire, but better results will be obtained by heating the articles in a closed muffle furnace, so as to obtain uniformity of heating and coloring. For some kinds of work more uniform results may be obtained by using a weaker solution, as one part of the concentrated solution to two parts of water.

Referring Vacuum-Gage Reading to 30-In. Barometer—What is the rule for converting vacuum-gage readings to inches of vacuum referred to a 30-in. barometer? For example, when the barometer stands at 30.8 in. and the vacuum-gage reading is 26 in., neglecting differences due to variations of temperature, what would be the vacuum referred to a 30-in. barometer? S. R.

When the barometric pressure of the atmosphere is 30.8 in., a vacuum gage reading of 26 in. of mercury column would indicate an absolute condenser pressure of 30.8 − 26 = 4.8 in. of mercury, and for 30-in. barometer, the same absolute pressure would be equivalent to 30 − 4.8 = 25.2 in. vacuum. Hence, to refer vacuum-gage readings to a 30-in. barometer, neglecting allowance for difference of temperature, subtract the actual reading in inches from the actual height of barometer and subtract this difference from 30; or, what is the same thing, add 30 to the reading and subtract the actual height of barometer.

Coal Chargeable to Use of Closed Heater—How much coal should be charged per 100 cu.ft. of water, heated from 60 to 200 deg. F. in a closed exhaust-steam heater? W. S. S.

The amount of coal chargeable will vary in different cases. The service should be charged with the cost of any increase of average back pressure on the engines; or on the other hand, if the heater acts like a condenser of the exhaust and reduces the back pressure, then the service should be credited with the improvement of economy resulting from reduction of the average engine back pressure. The increase or decrease of average back pressure on the engine, due to use of the heater, should be determined from indicator diagrams of the engine taken with the average load before and after the heater is installed. Then multiplying the pounds of coal originally required per pound m.e.p. per hour by the variation in back pressure will give the quantity of coal to be debited or credited to use of the heater.

Electromagnet Construction—Why is it that some electromagnets will operate on either direct current or alternating current, and others will operate on only one class of circuit? What is the difference in construction in a direct-current and an alternating-current electromagnet? W. A. S.

In a direct-current electromagnet the magnetic path is made of solid iron in some form or other. The coil is wound with wire of sufficient resistance to keep the current down to a safe operating value. In the alternating-current electromagnet, owing to the eddy currents that would be induced in the magnetic path if made of solid iron, the magnetic path must be laminated; that is, built up of thin sheets. The eddy currents induced in the magnetic circuit, if made of solid iron, would cause excessive heating. To prevent the alternating-current flux from causing the magnet to chatter, a shading coil is generally used. This coil consists of a loop of copper around one of the poles of the magnet.

In any alternating-current coil the current is limited by two factors—the resistance of the coil and the induced electromotive force. Consequently, a coil used on an alternating-current magnet, of the same lifting power as a direct-current magnet, will have considerably lower resistance than for the latter type.

Small magnets, such as used for ringing bells, can be constructed so that they will work on both direct and alternating current. This is because an efficient magnet is not required and the magnet is in service only for very short periods. However, it will be found that the magnet will be considerably stronger when used on a direct-current circuit than when on an alternating-current circuit of the same voltage. With large, well-designed magnet coils it will be found that if a direct-current magnet is connected to an alternating-current circuit of the same voltage that the coil is designed for, practically no current will flow through the coil owing to its high inductance. On the other hand, if an alternating-current magnet is connected on a direct-current circuit of its rated voltage, the current taken by the coil will be excessive and the coil will in a very short time reach an excessive temperature.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications.—Editor.]

Construction and Operating Costs of Water Power in Maine

By H. K. BARROWS* and EDWARD F. MILLER†

An interesting and able presentation of the conditions that influence the cost of power, whether it be steam or water. The article is part of a report by these engineers to the Public Utilities Commission of Maine, which deals with a special water-power investigation.

THE cost of power is fundamentally affected by the type of prime mover, in the case of units of about 500 hp. particularly. The manner of use of the plant, however, is an important factor in the cost of power, whether the source be water or steam. For illustration, a plant in use but ten hours of the day is spending a large part of its time in idleness, and the item of fixed charges for such ten-hour power would obviously be relatively greater than if the plant were in practically continuous use. The variation in load to which the plant is subjected is another important factor affecting the cost of power, and here again a plant which is supplying a power demand varying between wide limits is obviously at a disadvantage in respect to the cost of power produced.

Load Factor—Technically, the relation between average and maximum load at a plant is called the load factor, with some further reservation as to the time to which this applies. So we speak of the daily, monthly or yearly load factor usually with reference to the time during which the plant is running. The amount of machinery required is obviously inversely proportional to the load factor, and a high load factor means that a machine is running with little variation in output and therefore with greater economy than if a low load factor prevailed. For central stations load factors as low as 30 to 40 per cent. are not uncommon, while with industrial plants load factors as high as 80 or even 90 per cent. are sometimes reached. The raising of the load factor in the central station is one of the continual aims of efficient operation, meaning, as it does, a building up of the load curve in those parts of the day when the ordinary use of power is at a minimum. To bring this about means a judicious blending of customers with varied power demands as regards time of day. It is especially desirable to obtain, if possible, power users for the night period, from, say, 8 p.m. to 6 a.m. This means including considerable 24-hour power, or more particularly power uses such as for pulp and paper manufacture, electrochemical work, pumping, etc., which can be carried on during the night hours and in part limited to these hours.

Capacity Factor—Capacity factor is a term which takes account of not only load factor but the proportion of the time during which the plant is running. It is defined as the ratio between the total output of the plant as run at its rated capacity, 24 hours per day, the entire year, and the actual output of the plant in the same period. Obviously, for a plant running 24 hours per day, 365 days per year, the load factor and capacity factor are the same figure, provided that the rated capacity of the plant is the same as the maximum load demand or, in other words, that no spare power units are included. The load factor and capacity factor are always less than unity.

Diversity Factor—Diversity factor applies particularly to the use of power and takes account of the fact that all customers do not simultaneously require current enough to run their connected loads to full capacity, but have a diversity of demand; hence, the number of kilowatts of station capacity is always less than the number of kilowatts of connected load. If there were no losses of current in the transmission lines, the total true diversity factor would be the quotient obtained by dividing the total connected load by the station peak load. The actual diversity factor would be somewhat modified by losses of power in the transmission lines.

Comparative Utility of Water and Steam Power—Fundamentally, the hydraulic turbine has a great advantage—with an efficiency of about eight times that of the steam engine or steam turbine, and lower operating costs. It might seem at first thought, therefore, that water power would always be cheaper and more desirable. The usual high first cost of a water-power plant, almost always greater than for a steam plant, means greater fixed charges. Moreover, for inland water power to compete with steam plants adjacent to tidewater a considerable additional annual cost for transmission lines must be charged to the water-power costs in comparing them with steam electric power.

Cost of Steam Power—The reciprocating steam engine is perhaps the most widely distributed prime mover in use, although, as previously noted, its field of use has in the last few years been considerably encroached upon by the steam turbine. For smaller units—that is, below 1000 hp.—the reciprocating engine is likely, all things considered, to be superior in economy to the steam turbine. For the particular scope of this discussion, however, with special reference to the relative economy of steam and water power, usually dealing with units of 1000 hp. or more, the comparison would be practically with reference to steam-turbine driven electric plants.

First Cost of Steam Plants—The cost of steam electric stations is usually expressed in kilowatts, or sometimes in horsepower, with reference to the rated generator capacity; that is, the full output of the generators at the switchboard. Under normal conditions, the cost with units of 1000 kw. and over, the total cost per kilowatt is between $80 and $90. The cost with small units may exceed this figure quite materially, while with very large units, for illustration, 25,000 kw., the cost per kilowatt is usually lower. For purposes of general comparison, $80 to $90 per kilowatt as the total cost of steam plant is a reasonable figure. This total cost per kilowatt of, say, $85 is made up normally of about $40 for the steam plant, $30 for the electric plant and $15 for power house, boiler house, etc.

In the Table I data are given of reported costs of steam and electric and total plant cost (not including power and boiler house) for selected good-sized central stations as given in the annual reports of the Massachusetts Gas and Electric Commission, for the years 1914-17 inclusive. Data for the individual stations vary considerably. The average results, however, appear to be fairly constant.

TABLE I. COST OF STEAM-ELECTRIC PLANTS FOR SELECTED MASSACHUSETTS CENTRAL STATIONS, 1914-17

	Cost per Kilowatt—		
Year	Steam Plant	Electric Plant	Total
1914	$40.70	$28.40	$60.10
1915	42.50	28.00	70.50
1916	36.00	24.60	60.60
1917	40.00	30.00	70.00
Average	$39.80	$27.80	$67.60

With cost of power and boiler houses included, of $15 per kw., the average cost of these plants would be $83 per kw.

Cost of Power from Steam Electric Plants—The cost of power is made up in general of two items, that of the fixed charges usually taken to include interest, depreciation, taxes and insurance, and the operating charges which, for a steam station, should include fuel, wages, repairs and miscellaneous items, such as the use of oil, waste, etc.

Interest is taken usually at 5 to 6 per cent., taxes and insurance at 1½ to 2 per cent., and depreciation at 4 to 5 per cent., all with reference to construction cost. Obviously, the depreciation of the different items of a steam plant will show large variation. Depreciation in the sense as ordinarily used is a function of the life of the plant, and as the different portions of the plant may have a life varying from 10 to 30 years, or even more, the depreciation

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tion of particular items may vary from 10 per cent. per year to as low as 2 per cent., a fair average for the whole plant being 4 to 5 per cent. The total annual fixed charges for a steam plant are, therefore, about 12 per cent. of its first cost.

Operating Costs — The important operating costs are those of fuel and labor. Coal consumption varies within quite wide limits from 5 to 6 lb. per i.hp.-hr. for small units to as low as 1.5 lb. per i.hp.-hr. for very efficient reciprocating steam engines. For steam turbine electric units of 1000 kw. or over, the coal consumption will be about 2 lb. per i.hp.-hr., or about 3 lb. per kw.-hr. at the switchboard. Labor costs, including engineers, firemen and helpers, are also a considerable item in the cost of power by steam. In the Table II data are given of operating costs and amount of fuel used for the several central station plants in Massachusetts for the years 1914-17, inclusive. In all cases in this report the ton of 2000 lb. is used:

TABLE II. OPERATING COSTS, ETC., AT STEAM ELECTRIC PLANTS FOR SELECTED MASSACHUSETTS CENTRAL STATIONS, 1914-17

Cost of Coal per Ton of 2000 Lbs.	Lb. of Coal per Kw. Made	Cost per Kw., Cents			
		Coal	Wages	Miscellaneous	Total
$4.00	2.75	0.55	0.19	0.14	0.88
5.00	....	0.69	....	....	1.02
6.00	....	0.83	....	....	1.16
10.00	....	1.37	....	....	1.70

It will be noticed that about 1.75 lb. of coal was required per kilowatt-hour at the switchboard, which would correspond to about 1.8 lb. per i.hp. At the pre-war cost of coal, the total operating cost per kilowatt-hour was about 0.88c., of which about 62 per cent. represented fuel cost, 22 per cent. wages, and the remainder miscellaneous costs. No data are available as to the average load factors at these plants, but it is probably about 40 to 50 per cent. With coal at $10 per ton, a total operating cost of about 1.7c. per kw.-hr. would result, about 81 per cent. of this representing the cost of coal. The future cost of coal is somewhat problematical.

Total Cost of Steam Power—The previous table gives estimated central-station operating costs with different assumed costs of coal. The total cost per kilowatt-hour of power would include the fixed charges on the cost of plant.

Assuming a total plant cost of $85 per kw., annual fixed charges at 12 per cent. would be $10.20 per kw., or 0.12c. per kw.-hr. with a 100 per cent. load factor and no allowance for spare units or excess capacity. It is to be noted that with no excess capacity or spare units, the item of fixed charges would practically vary inversely with the load factor. The actual load factor for these plants was probably from 40 to 50 per cent., so that the actual fixed charges would be perhaps about 0.40c., making some allowance for probable excess capacity at these plants.

The total cost of power at the switchboard at these stations would, therefore, be as follows for various different costs of coal:

Cost of Coal per Ton	Total Cost per Kw.-Hr.
$4.00	1.28c.
5.00	1.42c.
6.00	1.56c.
10.00	2.10c.

The cost of coal at various points in the State of Maine under normal and war conditions are as follows:

Location	Normal Cost	Max. War Cost
Augusta	$4.00	$12.50
Bangor	4.00	12.50
Lewiston	4.25	12.00
Portland	3.50	10.90
Average	3.94	11.98

Based on the results obtained at these central stations in Massachusetts, from which the figures formerly given were taken where coal averages $4 per ton, it will be noticed that the total cost of manufacture, including fixed charges, has been approximately 1.3c. per kw.-hr., which also represents fairly well the cost of steam power at ordinary steam electric stations in the State of Maine under pre-war conditions.

The cost of steam electric power at isolated plants has been covered in considerable detail for different conditions of operation in a paper prepared by William F. Uhl, published in the *Journal of the American Society of Mechanical Engineers* for November, 1918. In the Table III are given costs of power for a 1000-kw. steam plant based on data in this article, assuming a cost of $85 per kw. for the total cost of steam electric plant with the various costs of coal.

TABLE III. COST OF POWER IN CENTS PER KW.-HR. AND DOLLARS PER HP.-YEAR FOR 1000-KW. PLANT OPERATING 24 HOURS PER DAY, 365 DAYS PER YEAR

Cost of Coal per Ton of 2000 Lb.	Load Factor, Per Cent.			
	100	80	50	30
$4.00	0.79c.	0.90c.	1.25c.	1.58c.
	$51.50	$58.90	$82.40	$104
5.00	0.91	1.02	1.40	1.86
	59.50	66.70	91.60	122
6.00	1.03	1.14	1.54	2.03
	67.20	74.60	101	133
10.00	1.49	1.64	2.13	2.67
	97.50	197	140	175

For plants of larger capacity these costs would be slightly less. The agreement in cost, however, with that previously given for Massachusetts central stations (where the load factor is probably from 40 to 50 per cent.) is fairly good as will be noted.

Load factors obtained by various power companies in the State of Maine are as follows: Androscoggin Electric Co., 42 to 60 per cent.; Bangor Railway and Electric Co., 85 per cent.; Gould Electric Co., 85 per cent.; Rockland, Thomaston & Camden Street Railway, 60 per cent.; Central Maine Power Co., 55 per cent.; Cumberland County Light and Power Co., 50 per cent.; Rumford Falls Power Co., 95 per cent.

Assuming that future load factors may be built up to approximately 60 per cent. for miscellaneous power and lighting use, it appears that the cost of steam power for such service will be about 1.1c. per kw.-hr. at the switchboard based upon pre-war costs of coal as well as wages.

With coal at $5 per ton, this cost would be increased perhaps nearly 0.15c. per kw.-hr. It seems reasonable to conclude that a cost of 1¼c. per kw.-hr. at the switchboard is likely to be reached for the cost of power from steam-electric central power stations in Maine; that is, for stations in general adjacent to or near the coast.

The estimates made of the cost of constructing plants at undeveloped water-power sites in Maine show an average cost for the four principal rivers of $99 per horsepower. The average cost of all plants both developed and undeveloped is $107 per horsepower. The cost of individual plants will vary from $60 per horsepower as a minimum up to $250 or more where sites are not especially good or where conditions of development are difficult.

To indicate the general extent to which load factor affects the first cost of plant, the Table IV has been prepared.

TABLE IV. EFFECT OF LOAD FACTOR ON COST OF HYDRO-ELECTRIC PLANTS

Cost of Plant to Deliver 1 Hp. on Wheel Shaft with Different Load Factors						Per Cent. Increase in Cost Over That for 100 Per Cent. Load Factor		
100 Per Cent. Load Factor			80 Per Cent.	50 Per Cent.	30 Per Cent.	Load Factor, Per Cent.		
Equipment and Power House etc.	Other Costs	Total Cost	Total Cost	Total Cost	Total Cost	80 Per Cent.	50 Per Cent.	30 Per Cent.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$40	$210	$250	$260	$290	$343	4.0	16.0	37.3
40	160	200	210	240	293	5.0	20.0	46.5
25	175	200	206	225	258	3.1	12.5	29.1
30	70	100	108	130	170	8.0	30.0	70.0
25	35	50	66	85	118	10.4	41.6	97.2
20	40	60	65	80	107	8.3	33.3	77.7

In a general way a power development which costs $200 to $250 per horsepower is likely to be on a large stream tending to a moderate or low-head development under which conditions the cost of equipment and power house is likely to be at a maximum. For this case, therefore, the range in cost of equipment and power house has been taken from $20 to $40 per wheel horsepower. Similarly, a low cost of development at $60 per horsepower is likely to be a high-head development, with usually a moderate amount of water. This tends toward lower cost of equipment and power house, and the range here has been assumed from $20 to $25 per horsepower on the basis of 100 per cent. load factor. The relative costs of such plants with vary-

ing load factors are given in columns 4 to 6 inclusive, of this table, and in columns 7 to 9 inclusive, the per cent. increase in cost over that for a load factor of 100 per cent. It will be noted that for the upper limit in cost of development, $250 per horsepower, the per cent. increase in total cost due to the load factor being other than 100 per cent. varies from about 4 per cent. with an 80 per cent. load factor to nearly 40 per cent. load factor. With the low-cost plant assumed at $60 per horsepower, this increase in cost is about 10 per cent. for an 80 per cent. load factor and 80 to 100 per cent. for a 30 per cent. load factor.

With a load factor of from 50 to 60 per cent., which may be expected for conditions in Maine, the cost of plant may be increased from about 15 to 40 per cent. over that for a load factor of 100 per cent.

Cost of Water Rights—On the basis of development upon a 60 per cent. flow basis and 100 per cent. load factor used in estimating the cost of development for various rivers in Maine, an amount varying from $10 to $40 per horsepower represents the approximate range in cost of water rights. including land.

Cost of Power from Hydro-Electric Plants — Fixed charges on the cost of water-power developments, or the basis for annual cost of power, constitute approximately 10 per cent. of the construction cost, the variation being about as follows:

	Per Cent.
Interest	5-6
Depreciation	2-3
Taxes and insurance	1-2
Total	8-11

Operating charges, the principal items of which are wages and repairs, are low. These will naturally vary materially with the capacity of the station and with load factor. They will usually be 0.1c. or less per kilowatt-hour of power delivered at the switchboard for good-sized hydro-electric plant with a load factor approaching 50 per cent.

Assuming annual fixed charges at 10 per cent., their cost per kilowatt-hour for 24-hour 365-day power is given in the Table V, using the range in first cost and load factors as given in the previous table:

TABLE V. FIXED CHARGES FOR HYDRO-ELECTRIC PLANTS WITH VARYING COST OF PLANT AND LOAD FACTOR

Cost of Plant per Horsepower		Fixed Charges in Cents per Kw.-Hr. of Output at Switchboard			
		Load Factor, Per Cent.			
Total Cost	Cost of Equipment and Power House	100	80	50	30
$250	$40	0.41	0.43	0.48	0.56
200	40	0.33	0.35	0.40	0.48
200	25	0.33	0.34	0.37	0.43
100	30	0.16	0.18	0.21	0.28
60	25	0.10	0.11	0.14	0.19
60	20	0.10	0.11	0.13	0.18

The hydro-electric plants on the rivers considered would not deliver their full output for 40 per cent. of the year. The 95 per cent. or primary output is from 70 to 80 per cent. of the full output on these rivers with storage regulation, so that only about 5 per cent. less than the full output would result for the average year. Making this slight deduction and keeping in mind 50 to 60 per cent. load factor, as was assumed for future steam plants, it is evident that hydro-electric power can be delivered at the switchboard for from about 0.25c. to 0.6c. per kilowatt-hour for the range of cost of developments found on the rivers in Maine.

An economic study of transmission lines in Maine indicates the superiority of steel tower lines.

TABLE VI. ESTIMATED COST OF TRANSMISSION LINES

Distance, Miles	Capacity of Line, Kw.	Line Voltage	Number of Tower Lines	Number of Wires per Tower	Total Cost per Mile
25	5,000	66,000	1	6	$3,500
25	10,000	66,000	1	6	5,000
25	20,000	66,000	1	6	7,000
50	10,000	66,000	1	6	5,000
50	25,000	66,000	2	6	10,000
50	50,000	100,000	2	6	14,000
75	50,000	100,000	2	6	14,000
75	100,000	150,000	2	6	20,000
100	100,000	150,000	2	6	20,000

Cost of Transmitting Power—In Table VII is given the cost per kilowatt transmitted and the annual cost per kilowatt-hour for the different lines, assumed by Professor Hudson. The table shows that power transmission at a cost of about 0.10c. per kilowatt-hour or less is readily obtainable.

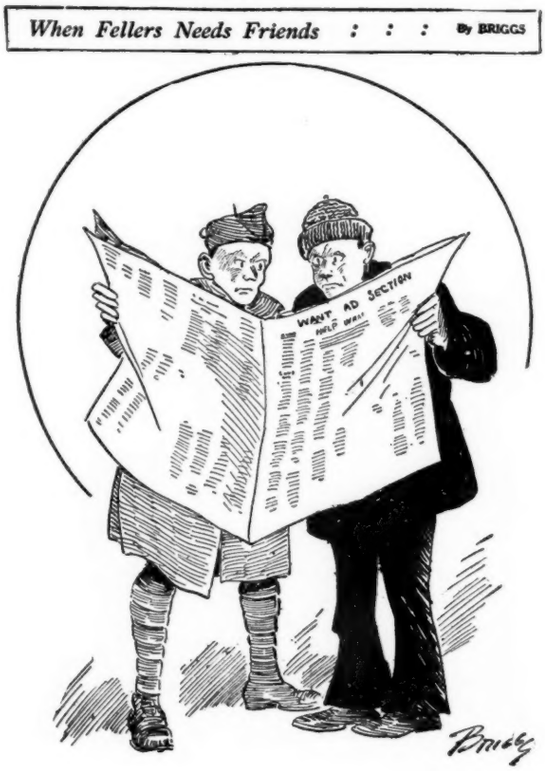
Cost of Storage Reservoirs—The average cost per million cubic feet of storage capacity is about $33. Storage on the Presumpscot River has already been developed and the extremely low cost of $10.79 per million cubic feet of capacity has been made possible by the great natural storage facilities of Sebago Lake.

Cost of Increased Primary Power Due to Storage — At developed sites on the six large rivers of Maine, this increase in primary power would be about 79,000 hp., costing about $34 per horsepower, or an annual cost, including operation, of $3.42 per horsepower. If all suggested power developments were made, a total increase in primary power of 168,000 hp. would result, at a total cost of $16 per horsepower, or an annual cost, including operation, of $1.60 per horsepower. To guarantee primary power with steam auxiliary means for annual fixed charges alone at least $7.50 per horsepower of plant, or more than double the average annual cost of storage, including its operation.

TABLE VII. ESTIMATED COST OF POWER TRANSMISSION

Length of Line, Miles	Capacity of Line, Kw.	Total Capital Cost of Line	Capital Cost per Kw. Transmitted (50 per Cent. Load Factor and 5 per Cent. Losses)	Cost per Kw.-Hr (With Annual Cost 25 per Cent. of First Cost)
25	5,000	$87,500	37	0.10
25	10,000	125,000	26	0.08
25	20,000	175,000	18	0.05
50	10,000	250,000	53	0.15
50	25,000	500,000	42	0.12
50	50,000	700,000	29	0.08
75	50,000	1,050,000	44	0.13
75	100,000	1,500,000	32	0.09
100	100,000	2,000,000	42	0.12

There is one additional factor not yet discussed, which would in general tend to increase the relative cost of hydro-electric power as compared with steam; that is, the including in annual costs of a fair return upon investment, in addition to that assumed of 6 per cent. In other words, instead of assuming 10 per cent, and 12 per cent., respectively, for annual fixed charges for water and steam plants, these should, to take allowance of investment considerations, be, say, 17 per cent. and 18 per cent. respectively, allowing 1 per cent. greater in this added factor for water power, on account of the greater risks involved.



Refrigerating Plant Efficiency*

By VICTOR J. AZBE†

The paper deals with the conditions prevailing in the majority of refrigerating plants and makes suggestions in regard to increasing the efficiency of their operation. The variations of the load factor should be considered in selecting the size of boiler. High boiler efficiency depends more upon design and intelligent operation than upon the quality of fuel used. The author condemns the practice of using a Corliss noncondensing engine for the prime mover on account of its large steam consumption when operated at fractional loads. He recommends the uniflow steam engine and the Diesel oil engine.

DURING the last two years the cost of fuel per ton of ice has doubled or trebled, and many plants are now paying from $1.50 to $2 per ton of ice for fuel alone, and the situation is becoming still more acute because of the shortage of labor, which is rapidly growing serious.

There are far more plants making on the average, per year, 1.5 to 2.5 tons of ice per ton of fuel than plants making 5 tons, having simple noncondensing plants in mind.

Fig. 1 is submitted as an illustration of the performance of a number of plants taken at random, showing both their

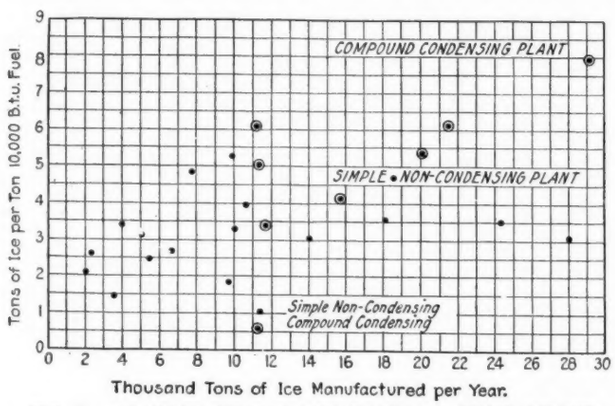


FIG. 1. YEARLY OUTPUT AND RATIO OF TONS OF ICE PER TON OF COAL

yearly output and the ratio of tons of ice made per ton of coal. For example, the plant of least capacity is one of 2000 tons per year and two tons of ice per ton of coal.

In this paper the writer will express himself frequently in terms of tons of ice per ton of 10,000 B.t.u. fuel, an expression that tends to equalize the value of the various fuels (semi-bituminous, bituminous, lignite, oil, etc.), since by a simple recalculation it places them on a common basis.

With waters that have a tendency to prime, it is often the practice to underload the boilers so as to prevent priming. In a certain plant having Stirling boilers and using water containing 80 grains of chlorides per gallon, serious trouble was experienced with priming until the steam connection was changed to the rear drum, after which it was possible to operate the boilers with water having a large amount of salt without any priming developing. In the same plant scale caused by calcium sulphate was overcome by adding sodium hydroxide to sodium carbonate and lime.

As the load factor of most refrigerating plants varies greatly, the boiler installation should be such as to give flexibility of operation. In small plants arrangements should be made to reduce the grate surface during the winter periods; each boiler must be equipped with a draft gage, and the draft should be maintained at the minimum and varied with the load.

With load factors as low as 35 per cent. and a 15 per cent. fixed and operating expense, a yearly saving of 30 per cent. of economizer investment will be made, based upon fuel at $2.50 per ton of 10,000 B.t.u. and normal economizer prices. At the present economizer prices are, of course, abnormal, and so is also the cost of fuel.

The prime mover most generally used in refrigerating plants is the Corliss noncondensing steam engine. Next in order are the compound Corliss, electric motor, oil engine, and uniflow steam engine. If this order were reversed, however, enormous sums of money would be saved to ice manufacturers, for the following reasons:

In selecting the prime mover for an ice plant, the two most important items to consider are efficiency at rated load and efficiency at half load. While the average Corliss noncondensing engine consumes 20 per cent. more steam at half load than at full load, the uniflow engine uses only about 8 per cent. more. This is of great importance because of the great variations of load factor. Many engines can be found operating at one-eighth cutoff. This is the reason, also, why a steam cylinder should be adapted to the back pressure at which the compressor operates. It is most unwise to have a steam cylinder large enough for economical cutoff at 25 lb. suction pressure when the pressure to be maintained is 15 lb. or less.

TABLE I. DIESEL POWER-PLANT PERFORMANCE

	Total	Per Net Kw.-Hr.
Wages paid	$4,545.10	$0.00405
Fuel-oil consumption	3,416.49	0.00305
Lubricating oil	466.86	0.00042
Repairs and supplies bought	1,116.50	0.00100
Repairs and supplies, home work	1,367.49	0.00122
	$10,912.44	$0.00974

MONTHLY RESULTS

Month	Total Power Generated, Kw.-Hr.	Total Power for Auxiliaries, Kw.-Hr.	Net Power Generated, Kw.-Hr.	Fuel Oil Consumed, Gal.	Cost of Fuel Oil per, Gal., Cents	Gal. of Fuel Oil per 100 net Kw.-Hr.
April	65,770	7,176	58,594	5,141	3.63	8.774
May	95,270	10,712	84,558	8,142	3.63	9.629
June	119,340	13,785	105,555	10,671	3.61	10.109
July	132,150	14,482	117,668	10,843	2.9	9.215
August	131,540	16,275	115,265	12,593	2.65	10.925
September	114,840	12,973	101,857	10,125	2.33	9.94
October	114,120	12,567	101,540	9,431	2.31	9.288
November	110,160	12,737	97,423	9,459	2.56	9.709
December	113,330	12,159	101,071	9,660	3.00	9.558
January	86,640	11,213	75,427	7,220	3.13	9.572
February	84,490	9,489	74,991	6,993	4.5	9.325
March	128,570	14,413	114,157	11,175	4.5	9.789
April	100,350	11,656	88,694	8,766	7.0	9.883
May	108,950	12,871	96,079	9,232	6.15	9.605
June	176,000	19,100	156,900	15,488	6.15	9.871
July	168,490	17,333	151,167	14,946	4.25	9.89
August	150,890	18,652	132,238	13,569	4.25	10.261
September	90,450	11,029	79,421	8,052	4.5	10.138
October	61,700	8,201	53,499	5,591	4.87	10.45
November	42,540	5,867	36,673	4,076	4.87	11.114

Fig. 2 shows the results to be expected from various types of installations. The allowance made for auxiliaries ranges from one-half to one horsepower per ton of ice, depending upon conditions. The condenser pressure was taken at 185 lb. gage, and it was assumed that at the suction pressure given the machine would operate at about full load.

In small plants preference should ordinarily be given to the use of superheated steam, since as high an economy may be obtained from a uniflow noncondensing engine operated with superheated steam as from a compound Corliss condensing engine using saturated steam, and the former equipment is a great deal simpler and requires less auxiliary power. Furthermore, the steam-consumption curve is flat and the efficiency of the plant will be maintained during the winter time.

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Superheaters can be installed with facility even in existing installations, and since the gain is greater with simple noncondensing engines, uneconomical ice plants will derive great benefit.

In the majority of ice plants the initial steam pressure in the steam cylinder is from 70 to 90 lb. Even in plants having high-pressure boilers the benefit to be derived from high-pressure steam is not usually taken advantage of. Tests show an economy increase of 7.5 per cent. by raising the pressure from 75 to 100 lb., and of 4 per cent. by raising it from 100 to 125 lb.

In order to gain in economy, a simple engine is often made to operate as a condensing engine. As a result the temperature difference in the cylinder is increased and the cutoff is shortened, which increases the wall area at cutoff as compared to volume. This greatly increases cylinder condensation, which is directly proportional to the temperature difference and the area exposed. It therefore sel-

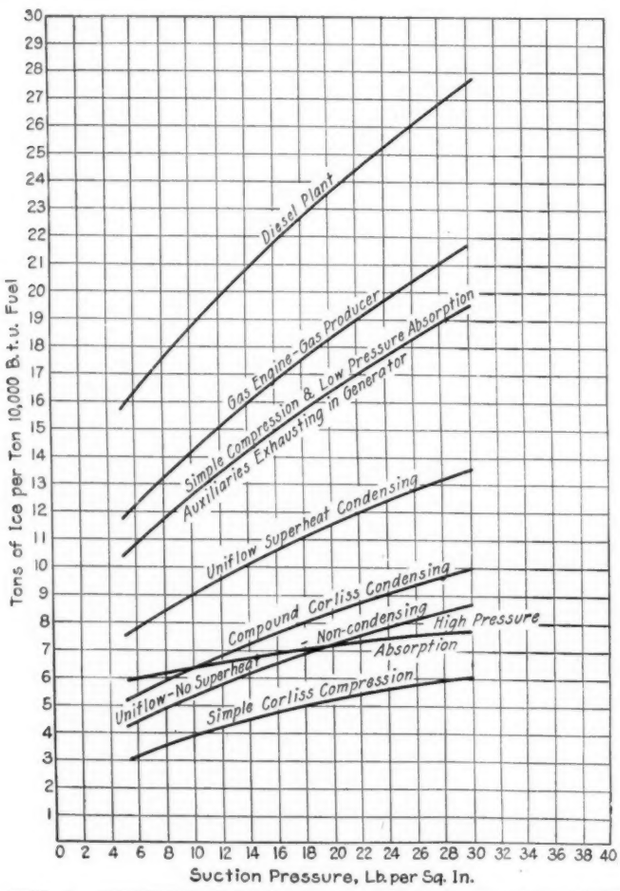


FIG. 2. PERFORMANCE TO BE EXPECTED FROM PLANTS WITH VARIOUS TYPES OF PRIME MOVERS

dom pays to operate such a machine at more than 20 in. of vacuum, and if the plant is to be changed over to condensing operation, it is best to replace the simple Corliss by compound cylinders or by a uniflow engine and leave the rest of the machine intact.

Under proper conditions the ideal and most efficient prime mover for the ice manufacturer is the Diesel oil engine. By "under proper conditions" is meant conditions of oil supply and cost, and kind of operating force to be employed. It cannot be overemphasized that with the Diesel engine a high-grade engine-room force must be maintained, especially during the overhaul period. If the men in charge are intelligent, the Diesel engine is a dependable unit. There is a plant in California that produces a ton of ice for 5 gal. of fuel oil, and this not under the best conditions. There are oil-engine installations on record, not necessarily Diesel engines, that have given a ton of ice for less than 10c. fuel cost, with oil at 2c. a gallon.

Table I gives the average results obtained with Diesel engines over a long period. The net work produced was 1,119,801 kw.-hr. The auxiliary power represented the power required for injection, in the air compressor, and in the water-jacket circulating pumps. The load factor having been highly variable, the results are not quite so good as they otherwise would have been, consequently the figures may be taken as being rather conservative and dependable.

In many localities electric power can be obtained quite cheaply, and when this is the case electric drive is to be favored. The main advantage of an electric installation is that high efficiency can be obtained through the whole load-factor range and that economy increases as the load factor drops, contrary to the condition in ice plants.

Induction motors are not very well adapted for ice-plant work because of the high speeds required for high efficiencies. Synchronous motors, on the other hand, have characteristics that make them ideal, even for direct connection to refrigerating machines. Their efficiency curve is quite flat, and their efficiency is rather high at part loads.

The standard requirement for auxiliary power per ton of ice produced should be 0.5 hp., and every effort should be made to keep down to this figure. In some plants the auxiliary power far exceeds 1 hp. per ton of ice.

For driving auxiliaries, electric current from generators driven by uniflow engines is to be preferred in the majority of installations, and the various units must be selected with a view to obtaining a flat efficiency curve between half and full loads; all motors on the larger units should have variable speed control.

Wet Versus Dry Compression

Theoretically, dry compression is inferior to wet, both in regard to refrigeration produced per pound of ammonia circulated and the work required for compression. The difference in economy ranges between 6 and 10 per cent., being greater with low suction pressures and high condenser pressures. Practically, however, dry compression is the more economical; that is, it is capable of producing a greater amount of refrigeration per horsepower expended. The reason for this discrepancy is that when wet gas is admitted into the cylinder the liquid is not suspended, but accumulates at the bottom of the cylinder. There it evaporates so slowly during the compression stroke that the evaporation continues after the discharge valve opens, and often even after it again closes when the piston is upon the return stroke, thus causing a certain amount of re-expansion loss which tends to reduce compressor capacity. Any liquid that evaporates after the discharge valve opens is wasted.

That there is no benefit in wet compression, as ordinarily practiced, is proved by the compression curve and its relation to the adiabatic and isothermal curves when the machine is operated wet, even to such an extent that the discharge gas leaving the compressor is saturated. In such cases the compression curve will only slightly approach the isothermal, which proves that most of the cooling of the gas by evaporation of the liquid is done after the compression valve opens and thus no benefit accrues from that time on.

To prove that the gas and the liquid do not mix and that the latter passes to the compressor in streamlike form, the following evidence is submitted:

Case 1. Two compressors of equal capacity and like design were operated upon two freezing tanks from which a single suction line led to a point midway between the two compressors. There it divided into two branches of equal size, one to each compressor. By faulty workmanship the line leading to one of the compressors was slightly lower than the one leading to the other, which caused the first machine to run with a cold discharge, while the other was very hot. This proved that all the liquid flowed by gravity into the first machine, the other receiving saturated gas only.

Case 2. In a vertical compressor having one discharge valve at the top and one at the bottom, it will be found, in wet compression, that the lower valve is cold while the upper one is very hot. This shows that the gas traveling to the lower valve in contact with the liquid will remain

cold, while the gas in the upper valve becomes superheated. So long as theory indicates an advantage in wet compression, it would seem that further studies and experiments regarding its successful application are justified. Could not some method be devised to atomize the liquid before it reaches the compressing cylinder, or to inject it in the form of a spray during the compression stroke? In any event precautions must be taken not to introduce liquid into the

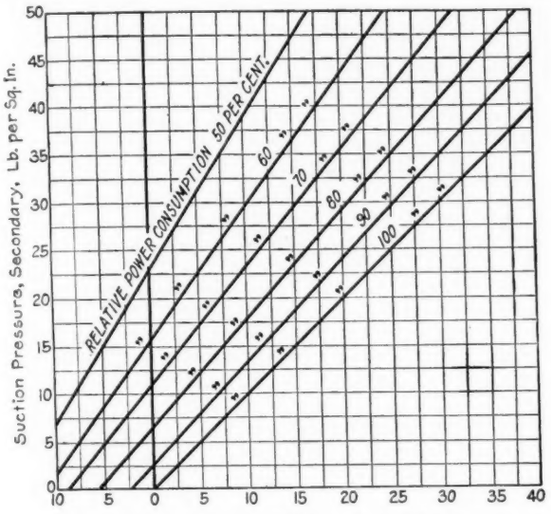


FIG. 3. INFLUENCE OF MULTIPLE EFFECT UPON COMPRESSOR POWER CONSUMPTION

cylinder in an undivided state, otherwise dangerous accidents are likely to follow.

Wet compression is not only beneficial upon thermodynamic principles, but possesses a number of other advantages. By its use the temperature difference in the cylinder is reduced by practically two-thirds, which greatly lowers the cylinder superheat and consequently should increase the volumetric efficiency of the machine. Further, with wet compression far less oil is required for lubrication and the oil does not vaporize and thus is easily kept out of the condensing and evaporating coils. Wet compression represents also a saving in ammonia and, in addition, permits a somewhat lower condenser pressure.

Ammonia Evaporating Systems

With expansion coils in ice tanks and cold-storage rooms a high heat transmission is very desirable, and it can be obtained inside of the pipes either by flooding them or by using a high gas velocity. The objection to high gas velocity in this connection is pressure drop, which for thermodynamic reasons is rather more important on the evaporating side than on the condensing side. For this reason the length of the evaporating coil should be limited so that the velocity will never exceed the average figure of 500 ft. per min. Some tank coils are 1500 ft. long and their rather high velocity causes a great pressure drop. For long tanks 2-in. pipe is to be preferred, since the relative surface of 1¼-in. and 2-in. pipe is in the ratio of 1 to 1.5, while the sectional area is in the ratio of 1 to 2.2. Coils should be short so that they are thoroughly effective, and even flooded coils should be as short as possible.

As to the size of suction lines leading to the machines, efforts should be made to have them below 100 ft. in length and with the least number of elbows. For greater lengths the size should be governed by permissible gas velocity, friction and radiation loss. The main considerations are the cost of fuel and the cost of installation.

In a well-designed and efficiently operated ice plant the water to be used for ice making is cooled down to within a few degrees of the coldest circulating water, or ordinarily to a temperature of 70 or 80 deg. F. This water then passes into the forecooler to be precooled by ammonia. The heat absorbed by the forecooler can be anywhere up to 30 per cent. of the total heat to be extracted in making ice, and the water will be cooled down to about 40 deg. F. There are two methods of forecooler refrigeration: By feeding liquid ammonia directly into a coil, or by passing wet return gas from the tank through the water cooler. The first has the advantage that it can be connected to a machine working independently from the freezing tank and thus enable the maintenance of very high suction pressure. The only advantage of passing the suction line through the forecooler is that the expansion valves on the tank can be kept open wider, thus insuring that the freezing coils will work throughout their whole length without danger of getting any liquid to the machine. But this same thing can be accomplished far better by means of liquid separators and it is of greater advantage to use the high suction pressure which is possible with direct feeding.

TABLE II. ECONOMIC EFFECT OF OPERATING COMPRESSOR INDEPENDENTLY ON FORECOOLERS WITH HIGH SUCTION PRESSURE

Case I	One Compressor	
	Back Pressure:	
	Ice Tank, 15 lb.	Forecoolers, 15 lb.
	Relative Amount Refrig. Work:	
	Ice Tank, 70 per cent.	Forecoolers, 30 per cent.
	Compressor Power per Ton of Refrig.:	
	1.74	
Case II	Two Compressors	
	Back Pressure:	
	Ice Tank, 15 lb.	Forecoolers, 35 lb.
	Relative Amount Refrig. Work:	
	Main Compressor, Ice Tank	Auxiliary Compressor, Forecoolers
	70 per cent.	30 per cent.
	Compressor Power per Ton of Refrig.:	
	Main Compressor, 1.21	Auxiliary Compressor, 0.32
	Total, 1.53	
	Saving over Case I, 12 per cent.	
Case III	One Compressor with Multiple-Effect Device	
	Back Pressure:	
	Ice Tank, 15 lb.	Forecoolers, 35 lb.
	Secondary Pressure in Compressor:	
	27.5 lb.	
	Compressor Power per Ton of Refrig.:	
	1.1	
	Saving over Case I, 34.7 per cent.	

Refrigerating plants should also be equipped with double-pipe liquid precoolers, cooling the liquid from the temperature of the coldest circulating water down to the temperature corresponding to the highest suction pressure used. In this connection a multiple-effect liquid receiver can also be used, by means of which a greater amount of work can be done at high suction pressure than by the use of the double-pipe cooler alone.

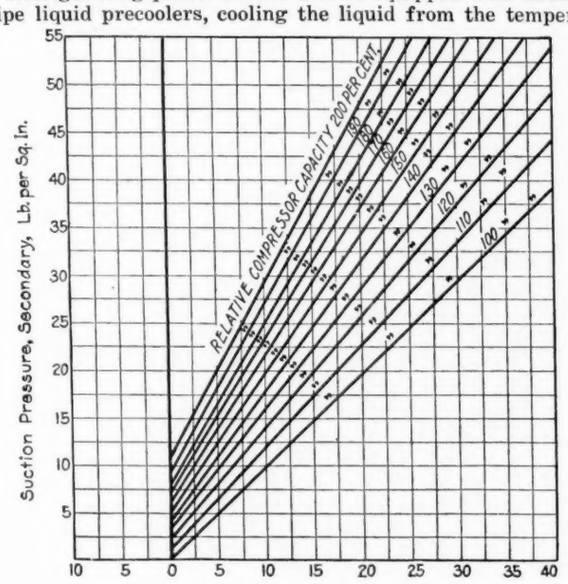


FIG. 4. INFLUENCE OF MULTIPLE EFFECT UPON COMPRESSOR CAPACITY

Every refrigerating plant should have an auxiliary compressor for high-pressure work. The size of this compressor may be relatively small for the reason that it will operate at double its rated capacity. Table II shows what economic

effect such a compressor will have by operating it independently on the forecoolers with high suction pressure. In addition to a saving of power equivalent to 12 per cent., the machine capacity will be increased 15 per cent. over all. There is also a decided increase in compressor capacity in cases II and III over I, especially in case III, where, with the same speed, there is a 50 per cent. greater capacity.

One of the most valuable inventions ever made in the refrigerating field is the multiple-effect compressor, which allows gas of higher suction pressure to enter the cylinder after it has been filled with gas of a lower pressure. Although it must be admitted that mistakes have been made in its application, there are installations where it is an absolute success. In a certain plant having sharp freezers and ice tanks, two compressors were operated for a long time, summer and winter, one upon low pressure and the other upon high. After adopting the multiple-effect device, the work was done without the slightest complications. With some compressors on the market it is very simple to use the multiple effect; with others, the arrangement is somewhat complicated. Table II shows the relative benefit derived from operating the forecoolers by means of the multiple effect.

Commenting further upon distilled-water coolers, which ordinarily are nothing but storage tanks with coils immersed, if the suction pressure is raised, the temperature difference will be reduced and a low temperature of the water will not be obtained unless more pipe is put in.

Since the circulation in such tanks is very bad, a much higher heat transmission can be obtained by circulating the water to gain some agitation. Fig. 10 indicates the influence of the multiple-effect method upon compressor efficiency. The curves are based upon 185 lb. condenser pressure and the York Manufacturing Co.'s data as to compressor horsepower required. Fig. 4 indicates the influence of mlltiple effect upon compressor capacity.

New England Engineers Annual Dinner

Over 300 members of the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, the Boston Society of Civil Engineers and other allied societies assembled at the Boston City Club Wednesday evening, Apr. 2, for the tenth annual Engineers' Dinner, which has now become an established event among New England engineers. The speakers were drawn from men prominent in National affairs, educational, manufacturing and engineering circles, and included George H. Moses, United States Senator from New Hampshire; Prof. George F. Swain, of Harvard University; Prof. C. A. Adams, president of the American Institute of Electrical Engineering; H. I. Harriman, president of the Boston Chamber of Commerce; and James J. Storrow, New England Fuel Administrator. Richard Rice, of the General Electric Co., Lynn, Mass., acted as toastmaster.

American Welding Society Holds First Meeting

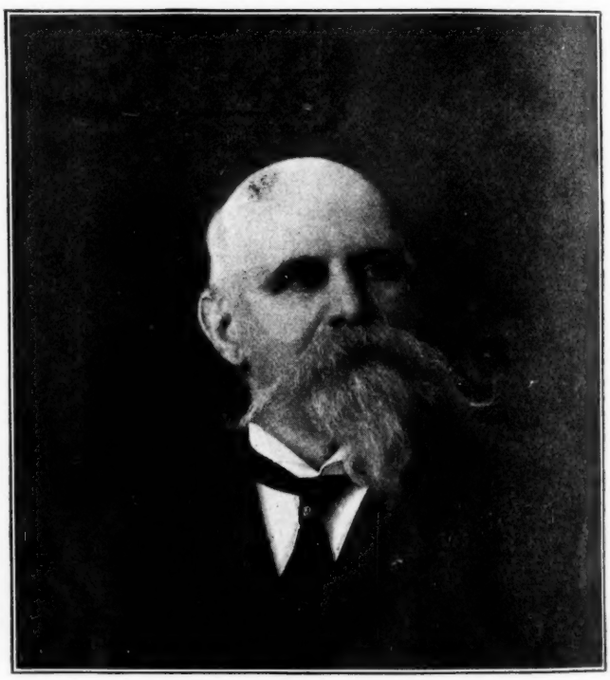
The first meeting of the American Welding Society was held on Mar. 28, 1919, at the Engineering Societies Building, 33 West 39th St., New York City, and the constitution and bylaws were adopted as recommended by the organization committee. The following officers were elected: President, Comfort A. Adams, Cambridge, Mass.; vice presidents, J. M. Morehead, New York, and G. L. Brunner, Utica; directors for one year—W. M. Beard, New York City; M. H. Roberts, New York City; M. M. Smith, New York City; L. D. Lovekin, Philadelphia, Penn.; Alexander Churchward, New York City; W. H. Patterson, Pittsburgh, Penn.; Walter J. Jones, Philadelphia, Penn.; C. A. McCune, New York City; directors for two years—R. R. Browning, New York City; A. S. Kinsey, Jersey City, N. J.; Victor Mauck, Conshohocken, Penn.; E. L. Hirt, South Bethlehem, Penn.; J. F. Lincoln, Cleveland, Ohio; H. M. Hobart, Schenectady, N. Y.; D. C. Alexander, New York City; H. R. Swartley, Jr., Jersey City, N. J.; directors for three years—L. H. Davis, New York City; E. L. Mills, New York City; D. B. Rushmore, Schenectady, N. Y.; James Burke, Erie, Penn.; D. H. Wilson, Jr., New York City; Hermann Lemp, Erie, Penn.; C. J. Nyquist, Chicago, Ill.; Alexander Jenkins, Baltimore, Md.

It was voted that the charter should be held open for ten days and that those applying for membership in the American Welding Society before Apr. 8 should be considered charter members. At a meeting of the directors in the afternoon, W. E. Symons was appointed treasurer and H. C. Forbes, secretary. The head offices of the society are in the Engineering Societies Building, 39 West 39th St., New York City.

For his inventions in electric welding Prof. Elihu Thompson was unanimously elected the first honorary member of the society. He was characterized by President C. A. Adams as the father of electrical engineering in this country.

Charles H. Manning

Capt. Charles H. Manning, for many years prominent in engineering circles in New England, died at Manchester, N. H., on Apr. 1. Mr. Manning was born in Baltimore, Md., June 9, 1844, and received his early education in that city and in Cambridge, Mass., later entering the Lawrence



CAPT. CHARLES H. MANNING

Scientific School of Harvard University to study civil engineering.

During the Civil War he served in the engineer corps of the Navy and became associated with Chief Engineer Isherwood in development work. He was later, in 1881, a member of the Advisory Board that prescribed the specifications for the so-called New Navy.

Leaving the Navy in 1882 after twelve years of continuous service, he accepted the position of chief engineer with the Amoskeag Manufacturing Co., Manchester, N. H., the largest cotton mills in the world, which position he kept until his death. He was the designer of the well-known Manning boiler and was associated with many pioneer power-plant designs, including a 2000-hp. horizontal water turbine, which at the time of its installation in 1885 was the largest of its kind.

He was a past vice president of the American Society of Mechanical Engineers, a member of the American Society of Naval Architects and Marine Engineers and of the American Association of Cotton Manufacturers, as well as a member of several clubs and smaller societies.

New Publications

STEAM ENGINE TROUBLES. By H. Hamkens. Published by The Norman W. Henley Publishing Co., New York City. Cloth; 5 x 7½ in.; 284 pages. Price, $2.50.

Readers of *Power* likely will remember the series of articles on "Steam Engine Troubles," written by H. Hamkens, and published in *Power* during 1917. These articles related almost solely to the Corliss type of engine and dealt with every piece of the engine from the foundation to the steam connections. They were profusely illustrated, and the text was written in that style so appealing to operating and erecting engineers. It was to be expected that such excellent material would be published in book form. And in the book the author has elaborated upon the original matter, making it treat of the slide-valve and other steam engines, as well as the Corliss. The man who operates a reciprocating steam engine will be pleased with the book.

Personals

William L. De Baufre, formerly in the engineering department of the Navy at Annapolis, has resigned to become associated with the Precision Instrument Co. as designing engineer.

C. E. Hague, formerly production engineer of the Mid-West Engine Co., Indianapolis, Ind., has been appointed sales manager of the American Steam Conveyor Corp., Chicago.

Capt. John W. Toyne, Utilities Officer, for the camps Chickamauga Park and Fort Oglethorpe, Ga., has received his discharge from the service and has reopened his engineering office at South Bend, Ind.

Lane Thompson, who has been connected with the sales department of the Lunkenheimer Co. at its headquarters in Cincinnati, Ohio, for many years, has been transferred to Pittsburgh to direct the company's sales in the western Pennsylvania district.

Ira W. McConnell, who has been connected with the Stone & Webster Engineering Corp. since 1912 as consulting engineer and chief engineer successively, and later as works manager and assistant general manager for the American International Shipbuilding Corp. at the Hog Island Shipyard, has been made vice president of Dwight P. Robinson & Co., Inc., constructing and consulting engineers, New York City.

Engineering Affairs

The American Association of Engineers, New York Chapter, will hold a meeting on the evening of Apr. 10, in Room 3, fifth floor, of the Engineering Societies Building, 29 West 39th St., New York City.

Business Items

The Epping-Carpenter Pump Co. announces the appointment of F. S. Healey as manager of sales in addition to his former office of chief engineer, vice E. F. Woods, who is now located in New York as Eastern sales manager. Albert A. Scheuch, of the sales department, has been appointed as assistant sales manager, and Paul D. Goodman, formerly of the McClary Jemison Machinery Co., of Birmingham, Ala., has been added to the sales personnel.

W. E. Becker and C. R. Smyth have organized under the name of Becker & Smyth, contracting engineers and sales agents for the Layne & Bowler Co., Chicago, Ill. Mr. Smyth has been for some time special engineer for the above company and previously was connected with the York Engineering and Supply Co., of Houston, Tex., as sales engineer for Busch-Sulzer Bros. Diesel Engine Co. Mr. Becker has been refrigerating engineer and salesman for the York Manufacturing Co., York, Penn., for the last twelve years and treasurer and manager of the York Engineering and Supply Co., Houston, Tex., for seven years prior to organizing with Mr. Smyth.

THE COAL MARKET

BOSTON—Current prices per gross ton f.o.b. New York loading ports:

Anthracite

	Company Coal
Egg	$7.80@7.95
Stove	7.95@8.15
Chestnut	8.05@8.35

Bituminous

	Clearfields	Cambrias and Somersets
F.o.b. mines, net tons	$2.15@2.75	$2.80@3.35
Philadelphia, gross tons	4.20@4.90	5.00@5.40
New York, gross tons	4.50@5.25	5.35@5.80
Alongside Boston (water coal), gross tons	6.10@6.85	6.90@7.65

Pocahontas and New River are quoted at $4.70 @5.25 f.o.b. Norfolk and Newport News, Va., for spot coal, and $7.20@8.60 alongside Boston, these prices being on a gross ton basis.

NEW YORK—Current quotations, White Ash, per gross tons, f.o.b. Tidewater, at the lower ports* are as follows:

	Mine	Company Circular		Mine	Company Circular
Broken	$5.95	$7.80	Pea	4.80	6.55
Egg	5.85	7.70	Buckwheat	3.40	5.15
Stove	6.10	7.95	Rice	2.75	4.50
Chestnut	6.20	8.05	Barley	2.25	4.00

Bituminous

	Spot		Contract	
South Forks	$2.90 @	$3.25	$2.95 @	$3.50
Cambria County (good grades)	2.80 @	3.10	2.95 @	3.25
Clearfield County	2.65 @	2.95	.....	.....
Reynoldsville	2.65 @	2.85	2.85 @	2.95
Quemahoning	2.85 @	3.10	2.95 @	3.10
Somerset County (best grades)	2.75 @	2.95	2.95 @	3.10
Somerset County (poorer grades)	2.40 @	2.75	2.75 @	2.95
Western Maryland	2.50 @	2.75	2.65 @	2.85
Fairmont	2.10 @	2.35	2.35 @	2.50
Latrobe	2.10 @	2.25	.....	.....
Greensburg	2.35 @	2.40	2.35 @	2.60
Westmoreland	2.60 @	2.75	2.65 @	2.75
Westmoreland run-of-mine	2.40 @	2.65	2.40 @	2.65

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

PHILADELPHIA—The price per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide are as follows:

	Line	Tide		Line	Tide
Broken	$5.95	$7.80	Buckwheat	$3.40	$4.45
Egg	5.85	7.70	Rice	2.75	3.65
Stove	6.10	7.95	Boiler	2.50	3.50
Nut	6.20	8.05	Barley	2.25	3.15
Pea	4.80	6.40	Culm	1.25	2.15

CHICAGO—Current prices per ton for Illinois and Indiana coal are as follows:

Illinois

Williamson, Saline and Williamson Counties	Southern Illinois F.o.b. Mines	Northern Illinois F.o.b. Mines
Prepared sizes	$2.55@$2.75	$3.25
Mine-run	2.35@ 2.50	3.00
Screenings	1.85@ 2.20	2.75

BIRMINGHAM—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared	Slack and Screenings
Big seam	$2.45	$2.75	$2.40
Black Creek and Cahaba	3.45	3.75	3.05
Jagger - Pratt Corona	2.85	3.05	2.45
Blacksmith	....	5.25	.....

Domestic quoations, slightly increased, are as follows:

	Lump and Nut
Black Creek and Cahaba	3.85@$4.50
Corona	3.40
Jagger	3.50
Montvallo	5.00

ST. LOUIS—The prevailing circular per net ton f.o.b. mines is as follows:

Franklin County		Mt. Olive and Staunton	Standard
Prepared sizes, lump, egg, Nos. 1 and 2 nut	$2.75	.....	.....
Williamson County Prepared sizes, lump, egg, nut	$2.55	$2.55	$1.90@2.25
Mine-run	2.35	2.20	2.00
Screenings	2.20	2.05	1.75
3-in. lump	....	2.30	.....
2-in. lump	....	.....	2.15

Williamson-Franklin rate to St. Louis is $1.07½; other rates 92½c.

New Construction

PROPOSED WORK

Conn., Hartford—The American Industrial Bank & Trust Co., 688 Main St., will install a steam heating plant in the 15 story, 56 x 156 ft. bank and office building which it plans to build. Total estimated cost, $600,000. Godly, Haskel & Ledwich, 244 Madison Ave., New York City, Arch.

Conn., Hartford—C. J. Burgess, 64 Brownell Ave., plans to install a steam heating plant in the 3 story hotel which it will build on Washington St. Total estimated cost, $150,000.

Conn., New Haven—The Pallootti-Andretta Co., 630 Chapel St., will install a steam heating plant in the 3 story, 76 x 490 ft. bank which it plans to build on Chapel and Olive St. Total estimated cost, $100,000. D. Guerriero, 647 Main St., Hartford, Arch.

N. Y., Brooklyn—The Board of Education, 500 Park Ave., New York City, will install a steam heating plant in the 5 story, 92 x 193 ft. P. S. No. 20, which it plans to build on North 4th and North 5th St. Total estimated cost, $457,000. C. B. J. Snyder, Municipal Bldg., New York City, Engr.

N. Y., Brooklyn—The St. Marks Amusement Co., 285 Flatbush Ave., will install a steam heating plant in the 1 story theater which it plans to build. Total estimated cost, $150,000. Carlson & Wiseman, 220 Henry St., Arch.

N. Y., Buffalo—T. & E. Dickinson & Co., 472 Main St., will install a steam heating plant and electric motors for power in the 5 story, 48 x 115 ft. factory and store which it plans to build. Total estimated cost, $170,000.

N. Y., Buffalo—The Sizer Forge Co., 244 Larkin St., is in the market for a 36 in. power shear, for use on 16 gauge metal.

N. Y., Long Island City—The Factory Construction Co., 44 Court St., Brooklyn, will install a steam heating plant in the 4 story, 100 x 200 ft. garage which it plans to build on North Ave. and the Boulevard. Total estimated cost, $350,000.

N. Y., Long Island City—The Famous Players-Lasky Corp., 485 5th Ave., New York City, will install a steam heating plant in the studio and laboratory which it plans to build here. Total estimated cost, $2,000,000. Fleischmann Construction Co., 531 7th Ave., New York City, Engr.

N. Y., Long Island City—The General Carbonic Co., 444 Van Brunt St., Brooklyn, will install a steam heating plant in the factory which it plans to build on 6th St. and West Ave. here. Total estimated cost, $200,000. Austin Co., 217 B'way., New York City, Engr.

N. Y., New York—The Greenwich Development Co., 44 Court St., Brooklyn, will install a steam heating plant in the 1 story, 85 x 140 ft. garage which it will build at 537-549 Broome St. Total estimated cost, $125,000. P. Deckman, Pres.

N. Y., New York—The Langdon Co., Inc., 85 Liberty St., will install a steam heating plant in the 15 story, 50 x 85 ft. store and loft building which it plans to build at 119 West 41st St. Total estimated cost, $600,000. Maynicke & Frank, 25 East 26th St., Arch.

N. Y., Watertown—The Ice Co. of Watertown, 80 Public Sq., plans to build and equip an artificial ice plant having a capacity of 15,000 tons. Address L. Washborn, c/o company.

N. Y., Watertown—The Water Board plans to equip a purification and pumping station with apparatus for making water analysis and alum tests. J. W. Phippen, Supt.

N. J., Trenton—The city plans to install 2 pumps in connection with sewer improvements. J. R. Fell, City Engr.

Penn., Erie—The H. P. Weller Co., 1302 Peach St., is in the market for a punch with 24 inch throat, capacity up to ⅞ in. through ¾ in. iron, driven with 220 a.c. 3 phase, 60 cycle motor.

Penn., Philadelphia—The Finance Co. of Pennsylvania, Finance Bldg., will install a steam heating system in the 21 story, 35 x 90 ft. office building which it plans to build at 1416-18 South Pennsylvania Ave. Total estimated cost, $1,500,000. Hoffman & Co., Finance Bldg., Arch.

Penn., Pittsburg—MacGovern & Co., Union Arcade Bldg., is in the market for a 2000 lb. Chambersburg steam hammer, single frame, offset type.

Fla., Bushnell—The city will require equipment in connection with installing continuous current for electric lights. Estimated cost, $10,000.

Tenn., Kingsport—The Kingsport Utilities Co. plans to remodel and improve its power plant here, and is in the market for power plant equipment to include the installation of Curtiss Type Turbines, generating 10,000 k.w. C. Thornburg, Ch. Engr.

Tenn., Kingport—The Union Dye & Chemical Corp. plans to build an ice plant and is in the market for machinery for same. J. B. Wilkinson, Ch. Engr.

Ohio, Cleveland—B. F. Keith Co., Hippodrome Bldg., will install a steam heating plant in the theatre and office building which it plans to build at 631 Prospect Ave. Total estimated cost, $1,500,000.

Ohio, Cleveland—The St. Luke's Hospital Association, 6606 Carnegie Ave., will install a steam heating plant in the hospital addition which it plans to build. Total estimated cost, $500,000.

Ohio, Lorraine—The Board of Education will install a low pressure heating plant in the 1 story, 125 x 200 ft. school which it plans to build. Total estimated cost, $125,000. Perkins, Fellows & Hamilton, 814 Tower Court, Chicago, Ill., Arch.

Ohio, Oxford—The city will receive bids about May or June for constructing 1 mi. of high tension transmission line, installing new electric pumps, and building 200,000 gallon elevated tank. Estimated cost, $40,000. L. A. Boulay Co., 1250 Nicholas Bldg., Toledo, Engrs.

Ind., Alexandria—The Ziegler Manufacturing Co. is in the market for a No. 00 Brown and Sharpe automatic screw machine, a No. 3 La Salle double and surface grinder and a Stoll overdriven power squaring shear for 73 x 3/8 in. soft steel.

Ind., Gary—The Eagle Theater Co. will install a steam heating and automatic ventilating system in the 1 story, 75 x 125 ft. theater which it plans to build on 16th St. and B'way. Total estimated cost, $125,000. D. S. Klafter, 64 West Randolph St., Chicago, Ill., Arch.

Mich., Detroit—The Board of Water Commissioners, 232 Jefferson Ave., will soon award the contract for furnishing 1 power hammer for forging iron up to 3 in. diameter.

Mich., Detroit—The Detroit Edison Co., David Whitney Bldg., plans to build a 30,000 k.w. addition to the Delray Power Plant, on West Jefferson Ave.

Ill., Chicago—The Board of Education has awarded the contract for installing a steam heating plant in the addition to the Davis Schol on West 39th St. and Sacramento B'lvd., to the Arcade Steam Heating Co., 126 West Kenzie St. Estimated cost, $22,316.

Minn., Brainerd—The Crow Wing County will install a steam heating plant and mechanical ventilation system in the 3 story court house which it plans to build. Total estimated cost, $250,000. Alden & Harris, 1011 New York Life Bldg., St. Paul, Arch.

Minn., Buhl—The St. Louis Co. School Dist. No. 35 will install a steam heating plant and mechanical ventilating system in the 3 story, high school addition which it plans to build on Chestnut St. Total estimated cost, $275,000. A. W. Kerr & Co., 524 Metropolitan Bank Bldg., Minneapolis, Arch.

Minn., Chisholm—The city will install a steam heating plant with mechanical ventilating system in the 2 story, 85 x 125 ft. auditorium which it plans to build on Main St. Total estimated cost, $100,000. A. Puck, Tarrey Bldg., Duluth, Arch.

Minn., Red Wing—The city will soon award the contract for the construction of a 100 x 100 ft. light and power plant; also new district system. Estimated cost, $350,000. L. P. Wolff, 1000 Germania Bldg., St. Paul, Engr.

Neb., Clarkson—The city will soon award the contract for rebuilding electric light and pumping plant. Henningson Engineering Co., 1122 Farnham St., Omaha, Engrs. Noted Oct. 15.

Mo., Columbia—The University of Missouri plans to build alterations to its power house. Estimated cost, $20,000. A. R. Hill, Pres.

Mo., Fulton—E. E. Reed, Pres. Westminister College, will receive bids about April 20 for the construction of a heating plant on the campus. Estimated cost, $25,000.

Mo., Richmond—The City Council is having plans prepared by Black & Veatch, Engrs., Interstate Bldg., Kansas City, for the construction of a new steam pumping plant at the city waterworks.

Ark., Springdale—The city plans to build a lighting plant. Estimated cost, $50,000. W. L. Winters, 700 South 20th St., Ft. Smith, Engr.

Tex., Corsicana—The Oil City Iron Works Co. is in the market for a power hammer, 100-200 lbs. capacity.

Man., Winnipeg—The Department of Public Works, Ottawa, Ont., will receive bids until April 16 for the construction of a 1 story, 110 x 122 ft. extension to the power house and laundry at the Military Hospital at Tuxedo. Equipment including 1 oil separator 3 x 4 in. automatic pressure reducing valve; two 10 x 14 x 16 steam driven single cylinder double acting, low duty, packed piston vacuum pumps; one 2 in., 2 stage vertical split case horizontal centrifugal pump; 1 hot water circulating pump; one 1½ in. horizontal centrifugal pump; 2 alternating motors, 2 hp., 3 phase, 220 volt, 60 cycle, 1800 r.p. min., will be installed in same. Total estimated cost, $75,000. R. C. Wright, c/o Dept. of Pub. Wks., Arch.

B. C., Vancouver—Gardiner & Mercer, Archts., 827 Birks Bldg., will receive bids about Apr. 10 for the construction of a 2 story, 54 x 125 ft. boiler and blacksmith shop for the Mainland Engineering Co., 732 Railway St., in connection with the engineering works which it plans to construct on Georgia St. near Coal Harbor. Total estimated cost, $70,000. Noted Mar. 18.

CONTRACTS AWARDED

Mass., Cambridge—F. H. Dow Co. has awarded the contract for the construction of a 5 story, 60 x 100 ft. factory on Main St., to include power house and refrigerating plant, to W. M. Bailey Co., 88 Broad St., Boston. Total estimated cost, $150,000.

R. I., Providence—The Providence Ice Co., 17 Exchange St., has awarded the contract for the construction of a 2 story, 90 x 135 ft. plant for the manufacture of artificial ice, to the Lord Construction Co., Fields Point. Estimated cost, $30,000.

Ill., Chicago—The Chappell Ice Cream Co., 1901 Webster St., has awarded the contract for the construction of a 1 story, 25 x 48 ft. garage and power house, to the Menke Thielberg Co., 139 North Clark St. Total estimated cost, $20,000.

Ia., Davenport—The Tri City Plate Ice & Cold Storage Co., 1433 West 2nd St., has awarded the contract for the construction of a 1 story, 35 x 55 ft. ice plant, to the Vilter Manufacturing Co., 872 Clinton St., Milwaukee, Wis. Estimated cost $50,000.

Minn., Duluth—The Clarkson Coal Co., foot of Birch Ave., Rices Point, has awarded the contract for installing electric convertor equipment, to the Westinghouse Electric Co., 605 Providence Bldg.; installing machinery for loading and unloading coal at dock, to the Mead, Morrison Mfg. Co. Total estimated cost, $125,000.

Mont., Miles City—The city received following bids for installing equipment in electric light and power plant: (a) 750 k.w. turbine generator, (b) 2 boilers, (c) stokers, (d) ash handling equipment, from the Westinghouse Co., (a) $16,972 (geared type), (a) $23,200, (direct connected), (c) $6635 (on Westinghouse); General Electric Co., (a) $17,825 (direct connected); Allis-Chalmers Co. (a) $17,900 (direct connected); Northwestern Electric Equipment Co. (a) $19,794 (direct connected) (b) $18,900 (on Murray), (c) $9116 (on combustion engine); Heine Safety Boiler Co. (b) $16,100 (on Heine); Babcock & Wilcox (b) $14,575 (on Sterling); R. B. Whitacre Co., (b) $17,630 (on Franklin), (c) $300, (on Riley), (d) $5032; Link-Belt Co. (d) $5461.

Que., Montreal—The city has awarded the contract for installing boilers at the waterworks to carry out tests with fuel oil, to the Imperial Oil Co., 918 St. Patrick St. P. E. Mercier, Engr. of the Dept. of Pub. Wks.

Read the

SEARCHLIGHT SECTION

The "Opportunity" advertising of the Power Plant Field

See pages 87 to 94